Phone: STerling 3-4100

INDEPENDENT TRACKING COORDINATION PROGRAM

824 Connecticut Avenue

Washington 6, D. C.

July 20, 1965

Dr. Thomas L. K. Smull
Director
Office of Research Grants and Contracts
National Aeronautics and Space Administration
Washington, D.C. 20546

Re: Research Grant NsG 35-60

Dear Dr. Smull:

Our last regular report was forwarded to you under date of April 20, 1965, and covered the period January 1 to March 31, 1965.

Enclosed please find Summary of Report and Activities for the second quarter period from April 1, 1965 to June 30, 1965.

A financial statement in the newly-prescribed NASA Form 1030-1031 for the same period is going forward by separate mail.

Respectfully,

Norton Goodwin
Program Director

Enclosures:
Report
Exhibits A through I

SUMMARY OF PROGRESS AND REPORT OF ACTIVITIES -

Second Quarter - April 1, to June 30, 1965

I. TRACKING AND DATA ACQUISITION

A. Observations and Reports of Fix:

1. PHOTOTRACK observations have been received at SPACOM during this period, as follows:

60 091	- 8	64 05A	- 1	65 09A	- 1
64 04A	- 6	64 76A	- 1		

2. During the period, the following observations have been received from independent tracking sources overseas and forwarded to Goddard Space Flight Center:

022 - 1	613 - 1	872 - 3
031 - 2	622 - 3	876 - 1
036 - 1	624 - 1	877 - 1
045 - 2	669 - 1	899 - 1
047 - 1	670 - 1	907 - 1
049 1 5	672 - 1	976 - 1
070 - 5	683 - 2	913 - 1
116 - 1	685 - 1	922 - 1
117 - 1	686 - 1	924 - 1
163 - 1	704 - 1	931 - 1
192 - 1	705 - 1	953 - 1
271 - 1	714 - 1	965 - 1
311 - 1	727 - 2	973 - 1
424 - 2	729 - 2	984 - 1
444 - 1	730 - 3	1089 - 2
446 - 2	731 - 2	1135 - 1
504 - 1	733 - 1	1137 - 1
513 - 1	740 - 7	1191 - 1
520 - 5	746 - 2	1192 - 1
506 - 1	751 - 1	1245 - 2
509 - 2	759 - 4	1270 - 3
527 - 5	761 - 1	1271 - 1
533 - 2	775 - 1	1272 - 2
534 - 1	784 - 1	1228 - 4
564 - 1	801 - 1	1291 - 2
574 - 1	811 - 2	1285 - 1
580 - 1	824 - 1	1310 - 2
594 - 1	861 - 1	1325 - 1
604 - 1	862 - 1	1326 - 1
605 - 1	864 - 1	1329 - 1
612 - 1	866 - 1	

A. 3. Fix reports listed above are in terms of apparent position as seen by the observer. In addition, fixes from independent observers in the form of positional elements on the following satellites (identified by catalog number) were received, as follows:

011	192	574
043	204	622
047	257	694
050	340	727
059	426	730
082	447	741
098	506	

The above fix reports were included in ITCP announcements as reported in I-B below:

B. Acquisition Data

1. Modified Orbital Elements from Independent Observers:

During the period mean orbital elements in the form of modified orbital elements derived by independent observers were included in ITCP airmail announcements on the following satellites (listed by catalog number):

862	864	1135

2. Gear Ratio Elements from Independent Observers

During the period positional elements in the form of gear ratio element sets derived by independent observers were included in airmail announcements on the satellites listed in Section A-3 above. In addition, complete sets of gear ratio elements (characteristic as well as positional) derived by independent observers on the following satellites were included in ITCP airmail announcements during the period:

1085	1088	1381	1385

- continued on page 3

B. Acquisition Data (cont.)

3. Current Gear Ratio Elements

During the period 1313 complete sets of current Gear Ratio Elements derived by NASA/GSFC from NORAD were included in ITCP airmail announcements. The number of current Gear Ratio Element sets per satellite is listed in Table 1 below.

TABLE 1

No. of Current Gear Ratio Element Sets Included in ITCP Airmail Announcements 1 April - 30 June, 1965

NCAT	No. Sets	NCAT	No. Sets	NCAT	No. Sets	NCAT	No. Sets	NCAT	No. Sets
00004	10	00062	10	00138*	1	00192	8	00255	9
00005	10	00063	3	00142*	3	00194*	1	00257	6
00011	6	00064	7	00144*	1	00196	4	00264*	2
00012	6	00069*	2	00145*	1	00202	2	00265*	1
00016	6	00070	4	00146*	2	00204	2	00268*	2
00020	6	00074*	2	00148*	2	00205	4	00271	9
00022	2	00079	4	00149*	3	00211*	1	00273	1
00023	9	00082	3	00151*	3	00212*	1	00274	2
00028	6	00099	6	00153*	2	00220*	3	00275*	1
00029	4	00101*	2	00155*	1	00223*	1	00285	6
00031	6	00105*	1	00156*	3	00226	2	00288	7
00036*	5	00107	4	00157*	1	00227	7	00299*	1
00043	6	00116	1	00158*	1	00228*	1	00300*	1
00045	5	00117	1	00159*	1	00230*	2	00309	3
00047	2	00120*	1	00161*	1	00233*	3	00311	4
00049	11	00123*	2	00162	3	00236*	2	00312*	1
00050	5	00125*	2	00163	6	00237*	1	00317*	1
00051	3	00126*	1	00165	4	00238*	1	00320*	1
00053	2	00129*	1	00166*	1	00239*	3	00321*	1
00058	4	00132*	2	00175*	1	00244*	1	00322*	1
00059	3	00134*	1	00176*	1	00245*	2	00325	1
00060	4	00136*	2	00188		00253*	2	00326*	1

*Since classified as "Space Debris"; see Sec. IV (EXHIBIT G).

Table 1 continued on page 4

Table 1 (continued)

NCAT	No. Sets	NCAT	No. Sets	NCAT	No. Sets	NCAT	No. Sets	NCAT	No. Sets
00328*	1	00466*	1	00564	6	00698*	2	00867	9
00329*	2	00467*	1	00573	12	00702*	1	00870	2
00333*	1	00468*	1	00574	9	00703	1	00871	2
00336*	1	00470*	1	00575	9	00704	2	00872	5
00337*	1	00473*	1	00580	12	00705	2	00876	6
00340	3	00475*	1	00582*	2	00706*	1	00877	2
00341	4	00476*	1	00602	4	00714	7	00878	5
00351*	2	00477*	2	00594	6	00715*	1	00893	1
00352*	1			00603	1	00716	1	00897	2
00353	1	00502	15	00604	1	00717	1	00899	3
00354*	1	00503	9	00605	1	00720*	2	00900	6
00355*	1	00504	13	00606*	1	00721	2	00902	1
00356*	1	00506	2	00608	7	00722*	1	00907	2
00357*	1	00508	12	00610*	1	00728	2	00913	12
00358*	3	00509	4	00611	1	00729	1	00922	5
00359*	3	00511*	2	00612	6	00730	2	00924	3
00369	2	00513*	4	00613	7	00731	2	00925	5
00370	6	00515	6	00614	8	00733	5	00931	9
00378	9	00516*	1	00622	8	00734	8	00932	3
00388	4	00519	5	00624	8	00735	8	00933	6
00397	2	00520*	3	00628*	1	00737	13	00947	10
00398	2	00523*	1	00630	7	00738	7	00948	3
00399*	4	00527	3	00645*	1	00739	1	00953	3
00401*	1	00531*	1	00646*	1	00740	9	00956	1
00402*	1	00533	2	00647*	1	00741	6	00957	15
00404*	3	00534	2	00652*	1	00744	11	00959	2
00405*	3	00535*	3	00653*	1	00745	1	00965	2
00406*	1	00536	2	00654*	1	00746	6	00973	9
00410*	1	00537	2	00655*	1	00759	6	00974	11
00413*	2	00538*	1	00658	2	00771	9	00978	9
00419*	1	00542*	1	00661*	2	00775	8	00979	6
00420*	1	00543*	2	00662*	2	00784	9	00983	6
00424*	1	00545*	1	00669	2	00801	3	00984	12
00426	8	00546*	1	00670	3	00811	8	00987	5
00444	15	00547*	2	00682	11	00812	10	00988	2
00446	2	00550*	2	00683	6	00813	10		
00447	1	00552*	3	00684*	2	00824	2	01000	2
00462*	1	00557*	3	00685*	5	00829	4	01001	2
00463*	1	00559*	1	00686*	5	00851	8	01002	5
00464*	1	00560*	2	00694	5	00864	11	01085	5
00465*	1	00561*	2	00696*	1	00866	15	01088	4

*classified as "Space Debris"; see Sec. IV (EXHIBIT G).

Table 1 cont. on P. 5

TABLE 1 (cont.)

NCAT	No. Sets	NCAT	No. Sets	NCAT	No. Sets
01089	6	01326	14	01366	1
01090	7	01327	2	01367	14
01091	8	01328	5	01368	1
01092*	4	01329	8	01369	1
01094 *	1	01330	10	01370	6
01097	4	01331	1	01371	6
01098	7	01332	1	01372	7
01099	4	01333	1	01373	6
01208	3	01334	1	01374	9
01228	12	01335	3	01375	4
01244	6	01336	9	01376	6
01245	3	01337	3	01377	7
01248	7	01338	8	01378	2
01249	16	01339	7	01379	3
01250	3	01340	10	01380	4
01251	2	01341	8	01381	3
01267	8	01342	9	01382	4
01268	7	01343	9	01383	4
01269	9	01344	7	01385	4
01270	1	01345	7	01389	4
01271	2	01346	6	01392	2
01272	4	01347	3	01394	2
01273	9	01348	5	01396	7
01288	13	01349	5	01397	3
01289	3	01350	2	01398	3
01290*	9	01351	7	01401	4
01291	2	01352	3	01402	3
01292	5	01353	1	01403	3
01293	7	01354	3	01404	3
01303	12	01355	9	01405	3
01310	6	01356	10	01406	1
01312*	7	01357	20	01409	3
01313*	5	01358	8	01410	3
01314	6	01359	5	01411	2
01315	6	01360	3	01412	2
01316*	5	01361	5	01417	1
01319*	3	01362	4	01418	1
01321	4	01363	7	01419	1
01323*	1	01364	1		
01325	1	01365	1		

*Classified as "Space Debris"; see Sec. IV (EXHIBIT G)

II. Efficient Communication of Mean Orbital Elements:

During the period arrangements were completed at Goddard Space Flight Center whereby each incoming 5-line element set of mean orbital elements from SPADATS/SPACETRACK are automatically stored in machine-processable form. A program for packing this numerical information into a 1-card format became operational during the period.

Beginning May 3, 1964, and every second Monday evening thereafter, the current two-weeks accumulation of NORAD 5-line element sets are processed and punched onto Hollerith cards as current gear ratio elements. These cards are made available for pickup at the Space Operations Control Center, GSFC, by 9:00 A.M. the following day.

Using these cards as input, the Independent Tracking Coordination Program now routinely supplies Current Gear Ratio Elements derived by NASA, GSFC from NORAD data on all unclassified satellites, as described in the enclosed Bulletin of May 4, 1965 (EXHIBIT A attached hereto).

Included in the May 4, 1965 mailing was a listing of Current Gear Ratio Elements accumulated as of the Modified Julian Epoch 38883.9 (May 3, 1965; EXHIBIT B attached hereto).

III. Change in Airmail Announcement Services

Prior to introduction of the new airmail announcement service inaugurated on May 4, 1965, ITCP had been sending out airmail announcements in which not more than 6 complete satellite elements could be transmitted at the single-card airmail postal rate. The new service permits packing over 540 complete sets of satellite elements in a 1/2 oz. airmail letter. The cost of printing and postage for the new service compares to that of the old although the useful information content is increased nearly 90-fold. Examples of airmail announcements in the new form are enclosed as EXHIBITS B, C, D, E, and F.

The fact that the new service permits supplying mean orbital data on many more satellites is obvious. The importance and usefulness of making the data available in an ordered, indexed form is less obvious. The new service is of unusual value to scientists who require data on a number of satellites. Herman F. Michielsen,

III. (cont.)

Senior Scientist, Aerospace Science Laboratory, Lockheed Missiles and Space Company, writes as of July 2, 1965:

> "As it stands now, I have a need to collect orbital data on a great number of satellites, without knowing for sure which ones. The only way to do this is to scan, every week close to a thousand sheets send to me by Goddard, and sift them. This burden was becoming a nightmare to me. And here came, all of a sudden, the one line elements, concentrating the same material in some six pages every two weeks - just for the filing! This is such a tremendous progress that I gladly will take the trouble, in time, to write a little routine to convert the information into numbers which my other programs will understand.
>
> "I thought I would let you know of my appreciation of this development. I know that you are not the type who would abandon an enterprise just because nobody lets you know he cares. But, on the other hand, abandonment of this new feature would be such a catastrophe to me that I decided I would take no risk."

Independent observers in remote corners of the world have also indicated their appreciation. We quote from a letter dated July 5, 1965 from Gregory Roberts in Durban, South Africa:

> "The new prediction bulletins are ideal and we welcome them. They make our work a lot easier, and as you say, they assist in identifying unknowns which, nowadays, we can identify 80% of the time. Recent examples are 62 Beta Kappa 1; 65 08B; 64 02BA, etc....."

IV. COMPUTER PROCESSING OF GSFC DATA

The punch card decks prepared every other week by GSFC include data on a large number of objects of no scientific interest. It will be borne in mind that SPADATS/SPACETRACK maintains elements on all objects which can be tracked by radar. These include hundreds of fragments of 1961 OMICRON, and a large collection of deapin weights from TIROS satellites, etc. Most of these objects are too small for optical tracking. None of them transmit. In the interest of supplying the most efficient service, data on such objects are suppressed

A computer program has been developed and is being used in the routine suppression of data on objects which have been identified as "space debris" Arrangements can be made to reinstate objects that have been classified as "space junk", as noted in ITCP Bulletin of May 26, 1965 (EXHIBIT G attached hereto).

V. LISTING OF RADIO FREQUENCIES

A number of independent observers continue to express interest in acquiring radio signals from transmitting satellites. A list of satellites believed to be transmitting as of JNL 38883 (May 3, 1965) was included in the airmail announcements mailed on May 17, 1965. (See EXHIBIT H attached hereto)

VI. INDEX OF IDENT DESIGNATION CORRESPONDING TO CATALOG NUMBERS 1208 - 1383

As new satellites are placed in orbit, additions to the Index for Satellite Identification published March 25, 1965 become necessary. The bulletin of May 26, 1965 (EXHIBIT G) included an Index of IDENT Designations Corresponding to Catalog Numbers 1208 to 1383. It is planned to issue a Cumulative Cross Index for every 500 unit increase in NCAT. And Index of Catalog Numbers for NCAT 0004 to 15000 will be issued during the next quarter.

VII. SIMPLIFIED PREDICTION METHODS

An increasing number of requests for information on simple methods for determining when and where to look for certain satellites are being referred to this office from NASA, the National Academy of Sciences-National Research Council, and other agencies. The need for a bulletin giving straightforward "How to do it" examples of local predictions from current gear ratio elements of the kind supplied in our announcement services is indicated. Such a bulletin is in preparation and will confine itself to simplified forms of satellite acquisition without taking into consideration those calculations that one would ordinarily make if one intended later to use the resulting observation for orbit improvement.

- continued on page 6

VIII. COMPUTER PROGRAMS

A. Individual Computer Programs

More and more people with access to intermediate and large-scale computers are writing to ITCP for tracking and prediction programs. A number of observers also appear to be in the process of rewriting programs furnished by ITCP to meet the input requirements of local computer facilities. ITCP encourages activities of this kind.

B. Requests for Diagnosis

In a number of instances requests have been received for assistance in "de-bugging" programs based on or derived from listings and write-ups furnished by ITCP. In order to conserve effort, ITCP has adopted a policy of declining such requests except in cases where a complete listing of the program and inputs are supplied.

C. Master Computer Program

Where observers have occasional access to computers with large core storage memory, a well considered master program can take care of the needs of a number of observers in tracking up to an hundred satellites. Storing all the program subroutines and historical data on tape between computer runs permits efficient preparation of a variety of prediction material as required, analysis of observed data and updating. A particularly well considered master program of this type is in preparation.

IX. IMAGE MOTION STABILIZATION SESSION

The Monday afternoon session of the Annual Conference, Society of Photographic Scientists and Engineers held May 17-21, 1965 was chaired by the Director of the Independent Tracking Coordination Program. The problem of atmospheric shimmer and its effect on telescope images was dealt with in a paper on "Image Motion Compensation in Ground-based Camera Systems" by Robert K. Weitbrecht of Stanford Research Institute. The converse problem of stabilization of images in satellite-borne image-recording systems was discussed by a panel, as noted on page 7 through 9 of the Program which has been attached hereto as EXHIBIT I.

X. Announcements and Bulletins

A. Postcard announcements on brighter satellites.

Date	No. Dist.	Identity of Satellites		
4/2/65	450	64 001C	64 004A	64 076B
		65 007A	64 076A	
4/19/65	451	60 009A	64 004A	64 005A
		63 053A	64 076A	62 060A
4/20/65	504	60 009A	64 005A	63 053A
		62 049B	63 049C	58 001A
		64 076B	63 007A	64 004A
		64 015A	64 076C	

B. Summary of Current Gear Ratio Elements Issued

5/3/65	712	210 satellites	(See Exhibit B)
5/17/65	687	160 satellites	" " C)
5/31/65	693	196 satellites	" " D
6/14/65	682	204 satellites	" " E
6/28/65	594	219 satellites	" " F

C. Summary of Permanent Gear Ratio Elements Issued

5/3/65	712	00031	00043	00050	00062	00204
		00257	00340	00426	00447	00574
		00622	00694	00741	00192	00098
		00204	00506	00780	00059	
5/17/65	687	00622	00059	00741	00043	00727
5/31/65	693	00047	00192	00257	1085	01391
6/14/65	682	01391	01385			
6/28/65	594	01003	01068			

End of Report

EXHIBITS ATTACHED TO THIS REPORT

A. ITCP Bulletin - May 4, 1965 - "Improved Airmail Announcement Services"

B. "Current Gear Ratio Elements Derived by NASA GSFC from NORAD Data as of 38883.9" (May 3, 1965)

C. "Current Gear Ratio Elements Derived by NASA GSFC from NORAD Data as of 38897.9" (May 17, 1965)

D. Same as of 38911.9 (May 31, 1965)

E. Same as of 38925.9 (June 14, 1965)

F. Same as of 38939.9

G ITCP Bulletin - May 26, 1965 - "1. Suppression of Space Junk" Data in Airmail Announcements; 2. Index of Ident Designations Corresponding to Catalog Numbers 1208-1383."

H. "List of Satellites Believed to Be Transmitting as of JNL = 38883 (May 3, 1965)"

I. PROGRAM: Annual Conference on Photographic Science and Engineering, p. 7-9.

EXHIBIT A

Phone: STerling 3-4100

INDEPENDENT TRACKING COORDINATION PROGRAM

824 Connecticut Avenue
Washington 6, D. C.

BULLETIN

May 4, 1965

IMPROVED AIRMAIL ANNOUNCEMENT SERVICES

Beginning today, the Independent Tracking Coordination Program will supply bi-weekly airmail announcement services in an improved form. The new format, which replaces bi-weekly postcard announcements limited to six satellites, will accomodate data on several hundred satellites in one mailing. In addition to one-line gear-ratio elements derived from "live" tracking agency data, the new service will list separately gear ratio elements received from independent observers during the same two-week period. Details on subscription rates and policy regarding unexpired "Phototrack" and "Moonbeam" subscriptions are supplied below.

The distinction between the kind of smoothed long-term elements derived by independent observers and the "live" data supplied by official tracking agencies is important. Although they may appear in the same kind of format, they are very different in character, and will always be listed separately. A discussion on Interpretation of "Live" Tracking Agency Data is given below.

Deadline for Receipt of Independent Tracking Data

Mean orbital elements in specified format must be received from independent observers on or before the close of business on the Monday preceding the scheduled mailing date in order to be included in the following day's listing.

Interpretation of "Live" Official Tracking Agency Data

One-line Gear Ratio Elements derived from "live" official tracking agency data are very different in character from the kind of gear ratio elements that are based on evaluation of a satellite position history over an extended period of time. As explained in the ITCP paper of March 19, 1965 on "Orbit Analysis and Improvement with Gear Ratio Orbital Elements", considerable improvement in accuracy of long-term prediction can be obtained through judicious analysis and smoothing of data that is supplied by the official tracking agencies. This does not imply that the tracking agency data is inaccurate. Generally, each set of elements derived by the tracking agencies represents a fresh determination. It is based on the most recent measurements and does not attempt to also account for previous history. If the tracking agencies smoothed this data, there would be considerable risk of losing objects that undergo unusual accelerations and it would be more difficult to quickly establish surveillance of new objects launched by foreign governments. In essence, tracking agency data must be "live" data and, as such, is subject to random variation in accuracy of measurement.

In his work of the past several months, W. P. Overbeck has demonstrated that the SPACETRACK data issued by the NASA Goddard Space Flight Center may be easily used to derive smoothed long-term orbital elements. Michael McCants has done similar work, using Modified Orbital Elements as a base. In both cases, the smoothing is accomplished with the aid of the Gear Ratio Elements format in which "standard" values are adopted for the Characteristic Elements as follows:

NGR, inclination	An average of several tracking agency values, supplemented by confirmatory observation.
CP, semimajor axis	Derived from long-term measurement of the mean anomalistic motion.
CG/CP, eccentricity	An average of several tracking agency values, supplemented by confirmatory observation.

One then proceeds to accumulate values for the Positional Elements; PRM, QNR and NRP, both from tracking agency data and observation. The QNR and NRP values are normalized and smoothed to develop a constant proportionality to the values of PRM, using the Gear Ratios, GR1 and GR2. As Overbeck's paper explains, the theoretical values for these ratios are initially adequate if they are based on the above mean values for the Characteristic Elements. Long-term observation will ultimately establish "observed ratios" that yield improved prediction results.

When this task of analyzing and smoothing both tracking agency data and observational data is done carefully, the results are quite rewarding. Generally, precise prediction can be obtained over intervals corresponding to more than 1,000 mean revolutions and, in some cases, this accuracy has extended for more than 7400 revolutions. The key to the success of these methods has been the determination of good values for the Gear Ratios, which appear to account for the secular motion of the orbit pole and perigee in a very simple and effective manner.

During the course of these developments, we have given considerable thought to a means for making the basic tracking agency data more readily available to others who may wish to do similar work and to express this data in a form that will reduce the calculational labor that is involved in the smoothing process. The ITCP Bulletin of March 26, 1965 on "Current Gear Ratio Elements in 1-Card Format" represents the first step in this direction. It uses data that had been supplied by volunteers to illustrate a compact and efficient means for communication of the tracking agency data. It also serves an important function in reducing the volume of records that need to be maintained by the recipient.

Arrangements have now been made with Goddard Space Flight Center, NASA, to supply NORAD/SPADATS mean orbital elements in a similar format, as defined below. NORAD data accumulated during the two week period ending Monday evening will be processed Monday night and included in our airmail announcements to be mailed on the following day.

In using this "live" data, one should recognize that it differs in character from the Gear Ratio data that we have supplied in the past. It eliminates all of the calculational effort that would be involved in conversion of units and adjustment to different points of reference but the data has not been smoothed and all items will reflect the random variations found in the source data. There are also a few differences in derivation that should be understood:

a. The value of integral mean revolutions, IPRM, starts from an arbitrary reference. In general, this will represent the number of mean revolutions from the time of launching but there may be some differences from values previously determined under the Gear Ratio system. The random variation in perigee position may also lead to some apparent discrepancies in the total revolution count. However, it is believed that, by careful comparison of successive values, these discrepancies can be easily detected and corrected.

b. The values of mean motion, APRM1, are based on current measurement rather than long-term measurement and will not necessarily agree with values obtained by differences in successive sets of elements. These values will also reflect random variations in the calculated rates of perigee motion.

c. The Gear Ratios will be calculated with the Kozai formulae represented by equations (26) and (27) in Overbeck's paper. However, they will reflect random variation in the Characteristic Elements from which they are computed. If one averages the values for several sets of elements, the results will closely approximate theoretical values that might be derived from the mean values of the Characteristic Elements in the same sets of elements.

d. Values of the acceleration coefficient, APRM2, are derived from current measurements rather than long-term trends in mean motion. In view of the resulting wide range in random variation, these values will not be expressed to a precision greater than ± 1 microturn/day^2. The user who wishes better long-term values should develop his own long-term analysis.

One-Card Format for Space Agency Data

The format for One-Card element sets described in ITCP Bulletin of March 26, 1965 has been modified to restore one more digit to the Modified Julian Date (JNE) and to GR1 and GR2 respectively. This has been accomplished by reducing the size of the field for giving acceleration in mean motion (APRM2) from 7 to 4 columns. APRM2 in the new format will be given in microturns, instead of hundredths of a microturn. An example of data as it will appear in the new format is given below.

Listings of One-card element sets derived from official tracking agency data will be printed with screen overlay to aid in distinguishing between the various fields. Decimal positions are implied (not printed). Each field column will be headed by its appropriate FORTRAN name, as described in ITCP Bulletin of March 25, 1965, with the exception of the column in which acceleration of mean motion is given. Because of space limitations, this field will be labeled M2 instead of APRM2. As in the earlier one-card format, the listed values of GR1 and GR2 are to be multiplied by 0.01.

Example

The following is a set of Gear Ratio Elements for PEGASUS received recently from W. P. Overbeck. They are expressed in the 2-line format he suggested in ITCP Bulletin of August 15, 1964.

```
1 65009A 38835.038192  .996508  .850943  000407  14.842777  10.0 WPO
2  .088166  06992.42  0113.88  -1.149519  +1.768327  00 351  14.842777
```

All of the above information can be punched in standard Hollerith coding on a single punch card with no significant loss in information as shown in the following:

NCAT		AJNE		ANRP		APRM1		ANGR		CG		GR2
1-5	[illegible]	10-15	[illegible]	22-29	[illegible]	34-41	[illegible]	46-51	[illegible]	59-64	[illegible]	73-80
01085	[illegible]	038192	[illegible]	850943	[illegible]	14842777	[illegible]	088166	[illegible]	011388	[illegible]	1768327

The above format will be used in listing one-card element sets derived by Goddard Space Flight Center, NASA from NORAD/SPADATS data.

Many observers will wish to consider sets of elements accumulated over time intervals longer than 1,000 days. In the revised format, epochs are unambiguously distinguished over a span of more than 27 years. In view of the "live" nature of the input data, limiting the accuracy of acceleration in mean motion to the nearest microturn per day squared is not significant. Any satellite that has an acceleration coefficient as high as 0.009999 will not last more than two or three more days, in any event.

Under some circumstances, satellites such as ECHO, exhibit a negative coefficient of acceleration. In this case, the first column in the M2 field will contain a minus sign (-). The units will continue to be microturns per day squared.

Format for Independent Observations

Gear ratio elements supplied by independent trackers will be listed after space agency data. The question of whether or not to express independent Gear Ratio data in the same 1-card format described above has not yet been decided. For the present, the Gear Ratio formats employed in W. P. Overbeck's paper on "Orbit Analysis and Improvement" of March 19, 1965, will continue to be used except that NCAT numbers will be substituted for IDENT numbers. Where there is any likelihood of ambiguity, FORTRAN names will be used to identify the variables supplied by independent observers.

Use of Standard Values for Characteristic Elements and Gear Ratios in Interpreting Data from Independent Observers

To maintain good coordination and correct interpretation of data supplied by independent observers, it is necessary that the characteristic elements (including the gear ratios) remain constant. For this reason, the Characteristic Elements and Gear Ratio Elements will not be printed with every set of position elements. In interpreting independent observations, the last previously published values will be regarded as the "standard values"

Instructions to independent observers wishing to offer improved Characteristic Elements and Gear Ratio Elements to replace "Standard Values" will be the subject of future bulletins.

Subscription Rates for Improved Announcement Services

The new announcement service increases to over 500 the number of sets of mean orbital elements that can be sent in a 1/2 ounce letter, as compared with the previous limit of six per postcard. Because of the appreciable increase in foreign airmail rates applicable to such 1/2 ounce messages, it will be necessary to increase the rates for future overseas subscriptions. The new schedule is as follows:

ANNUAL SUBSCRIPTION RATES FOR BIWEEKLY AIRMAIL ANNOUNCEMENTS
(Effective May 4, 1965)

United States, Canada and Mexico:	$3.25
Central and South America and Europe:	$5.50
Elsewhere:	$6.50

All ITCP Bulletins and special announcements are included in the subscription price.

Current subscribers to postcard service on the brighter satellites (Phototrack) and on transmitting satellites (Moonbeam) will have the unexpired balances of their subscriptions credited against the new service. Subscribers to both services will have the balances of their subscriptions applied consecutively.

Current Gear Ratio Elements Derived by NASA GSFC from NORAD Data as of 38883.9

EXHIBIT B

ICAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
00004887	3	10826625	5814388	103	32429	13817019	0108	092173073	34340608	31	-1041820	1557440
00004887	3	10826625	5814388	103	32429	13817019	0108	092173073	34340608	31	-1041820	1557440
00004887	7667558	1898364	83113		32492	13817276	0050	092173073	34250626	51	-1042430	1558350
00005886	9668510	6780518	75369		27823	10747244	0000	095092086	72301648	94-	0781460	1142620
00011887	2954577	4676322	59996		25887	11480818	0000	091286082	98641361	80-	0850720	1280060
00011887	2954577	4676322	59996		25887	11480818	0000	091286082	98641361	80-	0850720	1280060
00012887	4798731	8345271	84942		24479	11105842	0009	091373084	84451548	74-	0824370	1239630
00020887	6859489	9671269	34504		22684	11091123	0004	092561084	91991597	08-	0822400	1225900
00022887	2107868	9390459	80858		28709	14237214	0003	139775071	90610255	80-	0817640	0664930
00023887	0340150	8628420	42986		28736	14270855	0000	139742071	79330248	65-	0820310	0667580
00023887	5946581	7970841	06456		28816	14270947	0003	139704071	79270252	22-	0820610	0668380
00023887	5946581	7970841	06456		28816	14270947	0003	139704071	79270252	22-	0820610	0668380
00028887	5421187	2999203	09286		26870	14529521	0003	134437070	93680018	80-	0871420	0790250
00028887	5421187	2999203	09286		26870	14529521	0003	134437070	93680018	80-	0871420	0790250
00036887	0831874	6235367	74881		28084	15943445	0640	180466066	69906004	595-	0628360-	0077820
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00036887	5221532	5795107	61415		28154	15946426	0340	180467066	68230058	88-	0628540-	0077870
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00064887	0684175	5403853	94673		23613	14679711	0004	134726070	45210045	45-	0881710	0795220
00069887	4647067	8590497	62300		21323	13221167	0061	137166075	54400776	52-	0769590	0661540
00069887	4647067	8590497	62300		21323	13221167	0061	137166075	54400776	52-	0769590	0661540
00070887	7401568	5773982	66185		23498	15207212	0006	270518068	83340037	08-	0179210-	0639360
00074886	9343741	5838866	30640		23582	14671418	0001	134855070	47877005	941-	0880290	0792000
00074887	5547884	5033023	96630		23673	14671572	0019	134685070	47881005	415-	0881340	0795510
00079887	0832633	5656943	15707		23412	15221327	0019	270530068	79030033	17	0179540-	0640100
00099887	2820638	6384131	35893		27277	14888233	0014	142353069	79490121	48-	0849160	0650590
00099887	2820638	6384131	35893		27277	14888233	0014	142353069	79490121	48-	0849160	0650590
00101886	8820879	7507293	28406		27109	14713560	0003	134706070	34400033	95-	0884520	0798060
00105887	4199302	5406693	52722		21140	13054338	0109	140265076	18710824	71-	0741060	0596080
00107887	3080877	4344949	07940		19423	13340624	0001	079886075	07700643	56-	1042420	1690070
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00123887	3779007	4790990	07133		19644	14088870	0001	185274072	42140117	29-	0498350-	0137090
00125887	3033427	8679787	76554		19366	13896274	0002	185797073	08900075	73-	0485400-	0141910
00125887	3033427	8679787	76554		19366	13896274	0002	185797073	08900075	73-	0485400-	0141910
00126887	0841310	6878599	33633		19459	13985817	0001	185404072	77670078	86-	0492410-	0137570
00129887	0798606	1764608	57474		20643	14289669	0010	185249071	74150175	81-	0508370-	0139420
00132887	5846039	7501280	17632		19419	13904666	0000	185198073	05950055	29-	0490020-	0133570
00132887	5846039	7501280	17632		19419	13904666	0000	185198073	05950055	29-	0490020-	0133570
00134887	0463539	8898437	78199		19328	13893301	0001	185873073	09940068	47-	0484700-	0142920
00136887	5590188	0457813	69573		19466	13943068	0000	187751072	92580068	71-	0473500-	0169730
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00142887	0336711	7638872	74712		20372	14743569	0148	186539070	26210206	21-	0520280-	0165030
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00149887	4034806	6774925	97210		22696	14087599	0044	186510072	42600115	18-	0489270-	0154710
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00151887	6293882	6923315	26396		20402	14691098	0044	185932070	42910206	28-	0522510-	0155090
00151887	6293882	6923315	26396		20402	14691098	0044	185932070	42910206	28-	0522510-	0155090
00153887	6399894	8352846	31190		19506	13975253	0000	186491072	81360070	45-	0484060-	0152750
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00155887	0027155	8331078	56040		19375	13933942	0003	185819072	95730058	87-	0486960-	0142720
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00158887	1425339	8433597	89593		18772	12566328	0006	186334078	15800494	79-	0424420-	0131690
00159887	0867821	8574957	00630		18011	12943107	0000	182106076	63320360	3-	0466800-	0081210
00161887	5915657	2911647	69514		19853	14225867	0006	185585071	95590158	48-	0502750-	0143450
00163887	7994433	7817771	79973		12354	8917736	0001	253457098	23870074	32	0014860-	0341390
00165887	7205658	7336368	28647		19870	14351935	0002	133082071	52040033	59-	0865480	0804750
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00175887	6818579	2821246	14345		18927	13548829	0001	184988074	33280158	98-	0475210-	0126270
00176887	1570002	9343829	39165		19264	13847576	0033	185534073	26020055	139-	0484940-	0137560
00192887	7531879	7354935	07798		11141	8676943	0007	266345100	04710089	00	0067650-	0312610
00194887	6302699	5751063	27785		9003	8697623	0000	266226099	88850129	27	0067390-	0313910
00196887	0766582	7805822	90522		12260	8895596	0000	253323098	40160118	75	0014240-	0340380
00205887	7672977	0964210	89539		17130	13610189	0002	090044074	08450077	45-	1016010	1542480

Current Gear Ratio Elements Derived by NASA GSFC from NORAD Data as of 38883.9

NCAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
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00220887	05215112	08793203	678	20786	15304844	05421860	94068539	9010825-	0549820-	0166170		
00220887	44416201	75970195	374	20846	15307246	02831861	29068526	7010582-	0549630-	0166760		
00220887	44416201	75970195	374	20846	15307246	02831861	29068526	7010582-	0549630-	0166760		
00223887	02670259	55843782	915	19273	13853875	00001858	56073238	0005030-	0482950-	0142130		
00226886	94735052	47656160	055	16727	14347104	00021342	40071536	8006483-	0858190	0781140		
00227887	04272275	16911037	569	65858	14207670	00000133	69107200	40011850-	0850690	0782250		
00228887	72670968	86058323	009	16991	14477549	00041344	74071106	5002170-	0867050	0785730		
00230887	41289198	50660764	086	19390	13902552	00001185	84207306	70007293-	0485360-	0142620		
00230887	41289198	50660764	086	19390	13902552	00001185	84207306	70007293-	0485360-	0142620		
00233887	38553908	56708777	807	19384	13903303	00000185	81607306	44006660-	0485570-	0142270		
00233887	38553908	56708777	807	19384	13903303	00000185	81600000	00000000-	0485570-	0142270		
00233887	80986918	28089766	035	19443	13903478	00001858	73073063	8007197-	0485180-	0143070		
00236887	07399130	57842179	398	20216	14572058	00331871	73070812	3021293-	0507430-	0171840		
00236887	67101680	13665163	830	20303	14572251	00021871	51070811	7021429-	0507620-	0171530		
00237887	06799831	05458276	205	21197	14543094	00043187	19070906	3022609-	0506150-	0171510		
00238887	67256529	92005245	757	19650	14491965	00025186	45007107	27020746-	0509160-	0159960		
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00239887	51313185	56146437	546	20529	14853108	01391861	29069916	2018578-	0528500-	0160350		
00239887	77572235	35468434	786	20568	14853897	01681861	31069913	7018583-	0528520-	0160400		
00244887	71145168	87406788	051	19373	13857449	00011857	08073225	4005841-	0484190-	0140130		
00245883	75152718	39656475	964	19042	13879527	00021836	08073147	3005874-	0500150-	0110620		
00245887	38274455	87200419	029	19546	13879667	00021835	88073146	8005826-	0500300-	0110340		
00253887	05228969	11403760	997	19336	13902006	00041860	61073069	0005782-	0483740-	0145670		
00253887	84354098	58413744	097	19446	13902147	00181860	09073068	5007547-	0484160-	0144960		
00255887	74114977	57284701	359	17192	14995022	00015091	26206944	82002513-	1150330	1731180		
00257887	27169418	50974573	169	17116	14999820	00056091	21606943	33002419-	1151040	1732820		
00257887	56486978	01345623	044	17160	14999629	00093091	31806943	39002704-	1150550	1730800		
00264887	41885868	66133042	124	19273	13816790	00031849	23073368	8002827-	0487810-	0128570		
00264887	41885868	66133042	124	19273	13816790	00031849	23073368	8002827-	0487810-	0128570		
00265887	07744280	92684847	849	19920	14334945	00151851	30071590	4018291-	0511460-	0138270		
00268887	43463253	01511433	737	17175	12399521	00081886	60788577	054136-	0403000-	0157320		
00268887	43463243	01511433	737	17175	12399521	00081886	60788577	054136-	0403000-	0157320		
00275887	38648626	94202862	069	19495	13981689	00081855	22072791	0008512-	0491390-	0139180		
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00299887	02476595	15922178	596	18563	13553334	00001866	29074316	7016803-	0464110-	0148610		
00300887	80108826	34077837	190	19595	14025065	00091857	02072640	9007559-	0492100-	0142310		
00312887	63069481	19352654	361	14745	14153994	00001616	98072119	36023674-	0668950	0246050		
00317887	73002052	17832186	035	19800	14171415	00061844	95072139	8013287-	0508030-	0126840		
00320887	18015555	57001744	266	19640	14104590	00011859	39072367	8011992-	0494250-	0146830		
00321887	72028996	15006326	704	20510	14739064	00401862	17072767	3025051-	0523000-	0160220		
00322887	70729368	01228373	414	20385	14627839	00351864	05070632	0022864-	0516070-	0161350		
00323886	85003038	65610809	478	19322	13909800	00001857	02073041	6007160-	0486700-	0140760		
00323887	14477218	45784801	766	19363	13909836	00011857	13073041	5007343-	0486630-	0140910		
00325887	12458278	97624756	047	19344	13898710	00021859	54073080	5006681-	0484370-	0144130		
00326887	07239421	69064616	578	20230	14362461	00081860	33071499	2019609-	0506120-	0151940		
00328887	03881608	61258167	718	19959	14374211	00321853	60071460	0017456-	0511950-	0141370		
00329886	87194393	74625744	845	18906	13564709	00021856	44074274	9009040-	0471120-	0135350		
00329886	95303503	69253742	693	18917	13564634	00001855	91074275	2009732-	0471510-	0134630		
00333886	36538539	05374985	563	19000	14000006	00031856	46072727	5008705-	0492680-	0138600		
00336887	56471203	40123301	816	19015	13617294	00001862	11074083	7007036-	0469550-	0143760		
00337887	76855483	57825573	311	19007	13592560	00000186	16307417	36008961-	0468800-	0142780		
00340887	04728213	23293809	762	9264	91261660	00011244	21096719	8234658-	0565640	0605050		
00341887	65300592	81547854	579	9329	91357010	00012454	10966525	2342292-	0565890	0604260		
00351883	76894660	20588980	947	19170	13927111	00001855	64072981	0006008-	0488470-	0139040		
00351887	18659087	87790898	503	19646	13927295	00001855	22072980	4006138-	0488780-	0138450		
00352887	44236782	26569681	510	20666	15011171	03251848	85069424	4017310-	0545780-	0143170		
00353883	75834919	43644287	804	18912	13925064	00021849	31072988	1006634-	0492920-	0130050		
00354887	79861946	96603521	869	18730	13376481	00041863	16074970	1013971-	0458040-	0141840		
00355887	63510680	89370519	083	18581	13144347	00001867	54075850	1022413-	0445020-	0144380		
00356887	71938378	93577899	877	19412	13911135	00161869	07303700	07175-	0483420-	0147320		
00357887	46920990	79977652	300	19041	13741430	00001856	59073636	9001494-	0479070-	0137870		
00358887	03884431	28776819	408	20614	15082114	06671842	75069206	4014240-	0553850-	0134330		
00358887	43665460	95833815	220	20674	15084818	03331843	13069198	1013709-	0553650-	0134960		
00358887	64875850	78407807	364	20706	15086194	03101842	86069193	9014734-	0553990-	0134580		
00359887	01831599	85827123	022	20927	15602269	14331861	59067660	4007715-	0563420-	0171510		
00359887	31957779	58726126	414	20974	15607147	08361860	78067646	3007960-	0564340-	0170270		
00359887	31957779	58726126	414	20974	15607147	08361860	78067646	3007960-	0564340-	0170270		
00370887	06526233	90409971	138	14233	14660207	00042740	02070534	1006998	0199480-	0588940		
00378887	41465912	47077528	421	13924	14288198	00002742	78071752	6018002	0195170-	0568050		
00378887	70857002	55744499	460	13966	14287683	00002741	94071754	3016990	0194470-	0568450		
00397887	57114274	89127511	844	13860	14585327	00011620	04070763	4000499-	0692610	0249870		
00399887	07564477	11968398	555	13699	14490832	00011622	88071070	7003969-	0684700	0242540		
00401887	63282369	98764818	622	19335	13848660	00091862	72073256	5003301-	0479720-	0147850		
00402887	72401969	72186847	395	19246	13770708	00041852	75073532	4005549-	0483200-	0132930		
00405886	94693593	84848628	471	18881	13581499	00021858	94074213	8007495-	0470120-	0138960		
00405887	04273583	78831637	175	18894	13581383	00001859	08074214	2008C29-	0470030-	0139150		
00405887	55808363	45657618	943	18964	13581220	00001858	76074214	8007657-	0470240-	0138710		
00406887	25438974	98938695	498	18766	13469903	00001855	54074622	9010951-	0467410-	0132900		
00410887	14188790	87274576	697	19103	13718696	00001853	05073718	1001379-	0480500-	0132670		
00413887	13180759	73852859	024	19129	13755691	00151847	65073585	8001308-	0486030-	0125610		
00413887	71379469	35115905	744	19209	13755966	00401848	32073584	9001205-	0485580-	0126540		
00419887	37227654	58478568	048	18856	13526571	00031859	63074414	5009898-	0467180-	0139160		
00420887	52748896	73224810	590	19539	13997968	00001856	00072734	6009643-	0491630-	0140520		
00426887	08876549	07364940	048	12767	13660580	00007223	56907393	28001619-	0199720-	0521570		
00426887	63802698	92363932	630	12842	13660458	00002235	84073933	2001632-	0199610-	0521670		
00444886	94038700	40529927	539	9479	11262622	11881982	75084080	2182499-	0328510-	0252170		

Current Gear Ratio Elements Derived by NASA GSFC from NORAD Data as of 38883.9

NCAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	MR	ANGR	CP	CG	GR1	GR2
00444	88704	68815	03664	7922831	9491	11268	09	11756	19830	30840	530	182846	-0328700	-0252720
00444	88733	96722	02557	1916681	9524	11274	95	71238	19818	90840	188	182047	-0329410	-0251610
00444	88743	72205	02212	8913809	9535	11277	59	12891	19822	08840	057	181959	-0329250	-0252060
00462	88713	42447	05135	1268880	19350	13964	81	60000	18778	40728	501	007314	-0474260	-0170550
00463	88753	60121	71976	0891631	19487	13963	04	80011	18561	10728	558	006903	-0489830	-0140190
00464	88760	78950	97970	7304363	19991	14031	11	00111	18823	60726	206	012543	-0474150	-0177950
00465	88738	92385	68643	8246867	19395	13874	10	00012	18424	50731	665	005140	-0495360	-0119670
00466	88706	51339	32722	5783183	19778	14223	74	30004	18558	00719	631	015933	-0502690	-0143350
00467	88716	39914	06739	8969881	19808	13030	51	30001	18493	40762	907	026504	-0452160	-0119340
00468	88700	75600	92139	1342583	19242	13826	44	20011	18512	20733	347	008143	-0486960	-0131520
00470	88715	09960	78196	9237312	19797	13803	52	00009	18395	20734	156	006041	-0494080	-0114710
00473	88738	34196	55402	8654567	19652	14173	40	00048	18653	30721	335	013482	-0493180	-0156320
00475	88714	51492	12728	5209382	19408	13583	80	20003	18402	90742	650	017662	-0483580	-0113470
00476	88772	77228	15034	4530990	19322	13759	41	00005	18651	70735	729	005319	-0473900	-0149950
00477	88671	89530	52336	8955966	19487	14088	24	40022	18521	70724	336	010849	-0498690	-0136250
00477	88727	96874	48400	0942226	19566	14088	17	50005	18521	10724	298	010825	-0498730	-0136170
00502	88713	82397	24839	8342216	19107	13454	36	10047	19545	80746	825	085783	-0408600	-0264720
00502	88724	22830	24270	8338149	19121	13456	58	51210	19552	30746	742	086634	-0408440	-0265710
00502	88744	29153	23168	8330765	19148	13459	03	70774	19550	30746	652	086084	-0408540	-0265440
00502	88776	97945	21366	2319481	19192	13462	91	50630	19545	00746	508	085712	-0408990	-0264850
00504	88708	16777	42172	5453187	19887	12937	04	20333	19549	40766	991	05204	-0392010	-0254560
00504	88769	22495	39064	2327647	19966	12940	14	90252	19545	80766	476	105145	-0392370	-0254210
00508	88693	71902	03211	8207234	11349	14240	14	62759	19527	60719	098	058401	-0436270	-0279410
00508	88732	31695	00789	9190892	11404	14256	98	61998	19525	30718	532	058412	-0437140	-0279560
00508	88756	85832	99266	9181702	11499	14266	82	82041	19529	30718	201	058101	-0437190	-0280290
00509	88738	63477	64970	6531314	12453	14536	03	30004	25183	20709	381	001654	-0415510	-0655810
00511	88737	40089	89371	5945865	12759	13653	24	10042	22352	40739	599	002765	-0199820	-0520930
00511	88744	70131	89133	6907800	12809	13653	05	50002	22342	80739	599	002929	-0200640	-0520330
00513	88704	14414	24226	6346864	11106	13472	34	11131	19536	90746	160	084968	-0409740	-0263990
00513	88733	83132	25861	6336239	11164	13476	30	20023	19538	40746	014	085054	-0409860	-0264300
00513	88753	86399	21457	8327878	11171	13478	46	80641	19527	10745	934	085828	-0410940	-0263110
00513	88757	57346	21251	2326501	11176	13478	90	80621	19526	50745	917	086000	-0411060	-0263080
00516	88713	05811	71408	0378488	19204	13796	12	40005	18355	00734	318	007150	-0496590	-0108920
00520	88707	94172	38611	6432011	10933	13043	24	40403	19539	40117	559	132932	-0395580	-0255250
00520	88753	93608	36221	9415094	10993	13045	96	90289	19542	80762	527	100232	-0395630	-0255830
00520	88753	93565	36224	9414747	10993	13046	04	40300	19541	60762	324	100449	-0395780	-0255740
00523	88708	13977	60166	0528326	12269	14374	15	10016	25140	70714	674	006716	-0011430	-0646370
00531	88773	80016	75091	1196628	19932	14381	01	80058	18360	10714	371	026337	-0525800	-0116180
00535	88774	15719	17631	9043406	11850	14872	07	60020	27911	90698	874	014174	-0244290	-0565050
00537	88737	13961	37633	6532361	18086	12959	79	20009	18771	10765	885	023867	-0430530	-0153750
00537	88806	06636	45340	0215776	98	18176	12959	64700	01	18704	20765	690	030487	-0435450	-0145520
00538	88677	65763	19697	5080397	19457	13903	16	00031	18846	90730	649	005947	-0466510	-0178880
00542	88758	38917	25514	4873659	19515	13966	40	90004	18945	10728	449	005366	-0462190	-0193290
00543	88736	82357	38734	7374063	18978	13595	16	30000	18613	40741	61	006542	-0469060	-0142400
00543	88746	41491	38140	8411201	18991	13595	24	10007	18626	20741	886	006049	-0468140	-0144130
00545	88738	67191	56321	2162543	18903	13525	09	70000	18683	80744	201	013716	-0461230	-0150930
00546	88732	79778	69902	6332195	18750	13444	31	70018	18686	60747	176	011227	-0457240	-0150070
00547	88704	75470	15938	9402363	19115	13731	47	00005	18577	80736	500	002551	-0477540	-0139380
00547	88776	11789	11249	8380417	19213	13731	39	80000	18579	30736	500	002352	-0477640	-0139590
00550	88694	78362	28452	1310793	19047	13688	76	30004	18617	50733	900	004226	-0471040	-0144250
00550	88694	78555	28432	5313936	19067	13688	78	50010	18618	60738	286	003775	-0472060	-0145440
00552	88691	27837	78862	0878356	18789	13520	91	00022	18818	30744	970	010345	-0451580	-0168640
00552	88675	34147	07497	4878625	18873	13521	04	60040	18817	20744	352	008840	-0451620	-0168490
00552	88676	07904	27459	3847931	18883	13520	86	10013	18820	10744	359	010853	-0451470	-0168890
00557	88718	64812	83994	1883103	20153	14872	10	50114	18756	90698	569	015251	-0517840	-0182400
00557	88750	24160	81555	0865023	20200	14873	03	00000	18753	50698	540	015718	-0518190	-0181910
00557	88750	24523	81496	2871162	20200	14873	58	40144	18754	80698	523	015111	-0518070	-0182100
00559	88692	17142	90778	2929737	18944	13823	88	50001	18493	00733	437	009816	-0488250	-0128810
00560	88724	58599	28467	6521660	18771	13001	54	90008	18658	20764	043	034540	-0440760	-0140430
00560	88737	38003	27803	8481189	18783	13004	11	10225	18647	60763	943	037209	-0441860	-0139200
00561	88561	98653	47902	9584511	18013	12290	05	90001	18851	40793	251	057908	-0399710	-0153890
00561	88738	55159	39170	3551185	18230	12290	26	80013	18810	80793	242	057689	-0402180	-0149150
00573	88762	11797	40469	6660659	4601	63913	99	00001	18691	12264	914	92025	-0458120	0529500
00574	88711	40892	84512	0879776	6165	86528	61	00035	24250	51002	329	007352	-0030840	-0325070
00574	88749	93627	45046	2805892	6196	86525	90	00036	24258	31002	350	007248	-0030610	-0325130
00574	88770	73378	44977	5794624	6214	86516	70	00002	24236	81002	421	007923	-0031500	-0324880
00580	88742	02643	42016	3008488	10883	15986	00	82052	13594	30665	597	006003	-0979370	0862770
00580	88760	15556	39176	9021799	10912	15993	69	12118	13595	50665	383	006084	-0979910	0863040
00582	88702	72898	75949	3554059	10670	15822	48	92719	13656	10670	177	004348	-0961630	0836810
00606	88701	58276	97272	7430731	9868	14713	58	20002	16212	80742	736	001728	-0699870	0250500
00610	88713	55815	30197	0284411	9610	14229	13	20003	25059	80719	520	006938	0004790	-0637910
00611	88749	46540	93768	6290155	9958	14678	28	20014	24948	80704	772	009649	-0004270	-0665020
00612	88706	46698	33913	6473909	9336	14113	30	50014	13824	10723	259	043909	-0821670	0691130
00613	88707	79524	02327	8378121	10049	15214	10	90021	22869	50688	125	001744	-0186130	-0635260
00613	88770	88726	00551	6305946	10144	15214	16	10004	22868	30688	123	001704	-0186250	-0635190
00614	88700	06755	99235	5613992	7162	10893	47	00021	22800	40859	721	189105	-0135820	-0446530
00622	88701	67975	05415	3834720	5502	85791	77	00002	45765	10080	590	05500	-0017280	-0323820
00624	88732	67582	04735	4018578	5524	85883	87	00752	44891	10073	390	70582	-0021080	-0326940
00628	88721	40948	45238	0862205	6151	86324	53	00002	42730	10039	080	01752	-0029910	-0324230
00630	88757	02969	05283	9044485	5558	85974	31	00032	45654	10066	320	03163	-0017780	-0324660
00645	88778	02706	19761	8932977	18062	12914	25	40001	18503	30767	478	033687	-0446790	-0119370
00646	88714	16057	10695	4443804	20095	14457	04	20035	18660	10711	872	020978	-0506390	-0161670
00647	88750	30196	39998	2934026	19735	14141	54	70007	18536	00722	415	013197	-0500280	-0139030
00652	88756	86703	16138	4801543	19073	13659	51	50023	18540	40739	309	011615	-0477280	-0133340
00653	88701	03761	77128	7081736	18715	13455	06	00017	18732	70746	782	012946	-0454640	-0156360
00653	88754	54698	73857	4066969	18787	13455	02	20011	18749	30746	783	012884	-0453500	-0158540
00654	88726	24360	36088	3263649	19987	14375	35	20019	18708	60714	566	017218	-0498650	-0167390
00655	88559	12568	51137	5614166	17809	12934	88	60001	18682	60766	660	031159	-0435810	-0142450

Current Gear Ratio Elements Derived by NASA GSFC from NORAD Data as of 38883.9

NCAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
00658887	20270547	11242067384	19387139	21260000	01848690	7300	14004530		-0493140		-0129110	
00658887	47637246	91702163127	19425139	21541005	61848620	7300	04007134		-0493260		-0129030	
00661887	01134854	54305566454	18835135	44970002	31859530	7434	71009074		-0468070		-0139270	
00661887	37292444	31180535141	18884135	44985004	31858160	7434	70008853		-0469010		-0137420	
00662887	72305811	23706756907	18367136	91633000	81854550	7381	52007172		-0478280		-0134410	
00669887	57914680	20894925875	77311344	68430000	24977307	4715	51002313		-0001680		-0591530	
00682887	34253741	55626758839	84611601	00603213	24989806	6514	40002657		-0000940		-0746410	
00682887	54244661	55293748991	84931602	03492924	24991006	6485	90026624		-0000830		-0747050	
00682887	54242641	55347745857	84931602	04362953	24985906	6485	70024408		-0001320		-0747050	
00683887	18116415	95342663803	75611407	69400020	16364907	2457	73052387		-0656350		0211640	
00684887	06651874	37882811943	76321439	95300593	16281907	1371	00042695		-0680070		0232500	
00684887	38593674	06705822353	76781440	26020470	16273307	1360	80042862		-0680910		0234170	
00685886	96670122	14872737929	78031499	27562277	16379406	9476	61028330		-0707730		0225790	
00685887	13342431	97344743347	78281499	75771732	16379406	9461	20027177		-0707840		0225820	
00685887	34009041	74986749071	78581500	26591459	16375406	9445	50027722		-0708550		0226720	
00685887	63996871	43021759909	79031501	01251306	16373306	9422	50027035		-0709070		0227240	
00685887	63996791	42981759754	79031501	01371313	16372906	9422	40027143		-0709120		0227330	
00686886	88291405	95051359337	76321448	86760325	16618407	1078	80038744		-0660950		0173020	
00686886	97956615	85780367377	76461449	17520844	16615107	1068	70037359		-0661100		0173600	
00686887	37277045	48216372463	77031449	78950784	16613907	1048	70037990		-0661690		0173940	
00686887	37275465	47951370544	77031449	78260772	16615307	1048	90038640		-0661710		0173730	
00694887	41604823	86804191012	68561335	61990002	08430707	5019	60650006		-1028040		1622220	
00696887	58726692	90554398410	69161342	72320000	83485074	7546	051792		-1032810		1638260	
00698887	02944294	75103143171	67911332	92460001	08306407	5120	5052184		-1024390		1629180	
00702887	01732354	52161361829	6156	86529310	00024265	4100	23240019	29	-0030320		-0325180	
00703887	74236902	78691533104	68571348	34100000	24989207	4580	00000741		-0000800		-0593670	
00706887	48634362	78054525227	68061345	11210001	24989107	4699	2001452		-0000800		-0591780	
00714887	38327048	95841518105	61191248	45080018	21851607	8504	0083800		-0215480		-0442350	
00715887	58044252	78568535642	68161344	63460002	49929074	7169	001973		-0000520		-0591510	
00720887	38234607	09723707181	69741424	78190000	16337907	1876	8008617		-0662090		0217690	
00720887	57913106	90900752087	70011424	82400009	16234107	1875	1011046		-0669370		0236290	
00721887	23500239	02516518063	60861242	97830000	21841107	8734	2090229		-0215690		-0440620	
00722887	15637709	02968522526	60761243	77570015	21829807	8700	5088042		-0216360		-0439700	
00728887	07656645	96940334522	64711392	02520000	19421107	3006	7001093		-0425500		-0254240	
00730887	07884885	97103363066	64731391	95920000	19421407	3009	0000994		-0425440		-0254270	
00731887	61159535	65683322074	65451391	92040000	19420707	3010	4001051		-0425480		-0254180	
00733887	60842352	56168910722	65761421	81720000	27524907	1987	8003084		0201340		-0557700	
00734887	50608372	54166969167	65641422	12870001	27525307	1977	3001485		0201430		-0557820	
00735887	49159812	54006007345	65591421	49770001	27529507	1998	6001643		0201640		-0557230	
00737886	94270712	28296656845	3355	73955230	01912820	3111	2769274599		-0418940		0423160	
00737887	24018442	19206666411	3377	73960540	00011284	1711	1271627	3666	-0418030		0420810	
00737887	53767142	10730675761	3399	73951950	00001287	9111	1280327	0196	-0415580		0415830	
00739887	29811481	35391605399	68981359	73920002	08444507	4129	5054765		-1048000		1652270	
00740887	53941570	74340811666	60411329	10330144	22629107	5296	7018548		-0173080		-0518910	
00741887	14661570	88479965419	5975132	22200000	22642107	5557	7013230		-0170850		-0515710	
00741887	74409300	74920924156	60541322	21650000	22640307	5555	78013339		-0170990		-0515620	
00744886	82965712	62885824109	68271548	74260519	08734906	7966	4016544		-1221150		0095280	
00744887	31380711	71091964511	69021549	33300486	08732606	7949	1016503		-1221880		0097380	
00744887	71393780	95188082004	69641549	69010478	08733906	7938	6016402		-1222180		0098080	
00745887	26217000	21275903573	76891344	86750001	24981107	4708	3001997		-0001390		-0591640	
00746887	16510613	43872199953	3803	85071600	00071691	5510	1366	8334774	-0393850		0074060	
00746887	77636013	23455203724	3855	85071260	00021691	2810	1367	1334626	-0393880		0074330	

NEW LINE 1 ELEMENTS FROM:
W. P. OVERBECK:

1 00011 38818.080437 .004710 .452810 025256 11.480908 0.79
1 00043 38845.029276 .137755 .676390 026946 15.272119 5.75
1 00050 38869.040658 .976702 .924197 020864 12.197078 0.00
1 00082 38868.069602 .127198 .035331 018483 12.149866 1.42
1 00204 38864.024922 .224946 .909111 016970 13.630967 0.09
1 00257 38853.054324 .190580 .135178 016821 14.999184 10.2
1 00340 38868.062171 .336197 .795937 009242 09.126159 0.00
1 00426 38863.056683 .928545 .020841 012661 13.660495 0.08
1 00447 38853.041320 .223837 .701708 011839 13.379408 0.00
1 00574 38874.105574 .450808 .127079 006189 08.652535 0.00
1 00622 38869.141619 .055148 .033094 005491 08.579192 0.00
1 00694 38874.085050 .387877 .190100 006855 13.356462 3.41
1 00741 38819.055081 .208178 .327562 005282 13.222222 0.11

MICHAEL McCANTS:

1 00192 38875.108670 .572227 .331301 011120 08.676935 0.00
1 00098 38868.117556 .903087 .036444 010397 09.412857 0.00
1 00204 38868.133223 .167854 .995708 017026 13.630987 0.00
1 00426 38867.082906 .917674 .992184 012716 13.660486 0.00
1 00506 38867.099075 .352448 .594036 011762 13.797575 0.45
1 00730 38828.039592 .850067 .467725 13.920163 0.00
1 00059 38851.067385 .985100 .981571 022152 13.513093 0.19

Current Gear Ratio Elements Derived by NASA GSFC from NORAD Data as of 38897.9

EXHIBIT C

NCAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GRI	GR2
00004	88811	41420	13991	6557433	32540	13817589	0059	0921950	7334	1406	1869	-1042282	1557865
00004	88846	41547	06058	6675447	32616	13818114	0064	0921930	7333	9506	1624	-1042226	1557806
00005	88785	08018	60371	5984646	27918	10747224	0000	0950750	8472	1642	16	-0781059	1142150
00005	88854	86572	54490	0070513	27993	10747213	0000	0950610	8672	5216	3841	-0780843	1141962
00011	88729	54577	46763	2259996	25887	11480818	0000	0912860	8298	6413	6180	-0850728	1280062
00012	88827	22475	76187	2294564	24568	11059080	0007	0914050	8484	4215	5848	-0824996	1240265
00012	88905	56101	68886	2401851	24653	11059710	0005	0913820	8484	3155	204	-0824806	1239896
00016	88798	94670	89653	4089650	22198	10403683	0002	0951240	8862	3183	243	-0758598	1108878
00020	88809	12156	08550	43101623	22820	11091166	0003	0925840	8497	1599	907	-0827403	1225802
00023	88759	46581	70788	4106456	23014	14270947	0003	1397040	7172	7025	222	-0820622	0668378
00023	88809	21364	73885	5149109	23080	14271067	0003	1397996	7172	3025	973	-0820167	0666614
00023	88888	39279	64[illegible]	5220664	23080	14271121	0003	1398010	7172	[illegible]024	507	-0819919	0666374
00028	88734	21187	24[illegible]	0309286	23080	14529521	0003	1344370	7053	[illegible]001	880	-0821444	0790251
00029	88813	90471	25981	7317006	23080	14517432	0003	1346206	7053	[illegible]001	573	-0843316	0785632
00029	88902	20859	71[illegible]	5491552	23080	14517332	0003	1344570	7053	[illegible]002	231	-0843344	0788974
00031	88806	04440	19981	6269192	23080	15365809	0003	1422730	6834	[illegible]011	233	-0888179	0680242
00031	88866	52638	21[illegible]	6326923	23080	15366169	0003	1423396	6834	[illegible]011	133	-0885744	0678834
00031	88911	46842	05[illegible]	6374561	23080	15366483	0003	1423360	6834	[illegible]011	116	-0885787	0678914
00045	88790	04416	69[illegible]	6905105	23080	14171759	0003	1852830	7211	[illegible]021	680	-0902854	-0138469
00045	88842	72429	64[illegible]	6891491	23080	14171775	0003	1853090	7211	[illegible]021	625	-0902652	-0138861
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00049	88920	90167	98[illegible]	6939159	23080	12673174	0003	1314070	7177	[illegible]043	360	-0746209	0714825
00050	88850	28106	83[illegible]	7056471	23080	12197084	0003	1312480	7177	[illegible]009	338	-0707794	0677789
00050	88911	76643	78[illegible]	7101536	23080	12197089	0003	1312970	7177	[illegible]009	264	-0707844	0676989
00051	88911	14246	93[illegible]	6972242	23080	12178585	0003	1312470	7177	[illegible]008	565	-0706553	0676403
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00059	88913	98800	41[illegible]	6921105	23080	13513087	0003	0783640	7746	[illegible]014	097	-1057[illegible]	1719236
00062	88760	19081	58[illegible]	6740166	23080	12878582	0003	1388200	7177	[illegible]089	074	-0758[illegible]	0613065
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00062	88890	85254	60[illegible]	6841787	23080	12878804	0003	1387340	7177	[illegible]089	313	-0[illegible]	0614690
00064	88776	53861	44[illegible]	6479842	23080	14679887	0003	1348710	7746	[illegible]005	424	-0[illegible]	0792263
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00070	88854	24443	59[illegible]	6194361	23080	15207259	0003	1270544	7177	[illegible]004	118	-0[illegible]	-0639259
00079	88803	58540	58[illegible]	6220150	23080	15221443	0003	1270538	7177	[illegible]003	724	-0[illegible]	-0640078
00079	88833	73961	87[illegible]	6142922	23080	15221590	0003	1270534	7177	[illegible]003	998	-0[illegible]	-0640114
00082	88811	08460	98[illegible]	6167474	23080	12149848	0003	1078877	7177	[illegible]097	639	-0[illegible]	1083564
00099	88852	27586	84[illegible]	6269678	23080	14888400	0003	1422880	6974	[illegible]012	048	-0[illegible]	0651931
00107	88790	04033	78[illegible]	6128501	23080	13340639	0003	0798960	7178	[illegible]006	445	-1[illegible]	1690001
00162	88834	67411	98[illegible]	6835913	23080	14342314	0003	1330020	7178	[illegible]003	917	-0[illegible]	0805652
00163	88812	37577	81[illegible]	6161776	23080	8917807	0003	2532560	9178	[illegible]005	375	-0[illegible]	-0341470
00163	88876	07609	71[illegible]	6139822	23080	8916951	0003	2534390	9178	[illegible]006	846	-0[illegible]	-0341356
00163	88875	75741	83[illegible]	6183503	23080	8917867	0003	2535830	9178	[illegible]011	405	-0[illegible]	-0341396
00165	88897	63597	24[illegible]	6987213	23080	14351957	0003	1330230	7178	[illegible]003	445	-0[illegible]	0805945
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00192	88797	00651	34[illegible]	6347054	23080	8677016	0003	2663150	9178	[illegible]009	542	-0[illegible]	-0312690
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00192	88770	93515	30[illegible]	6306357	23080	8676914	0003	2665500	9178	[illegible]013	048	-0[illegible]	-0312236
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00196	88810	23887	83[illegible]	6235259	23080	8895614	0003	2533230	9178	[illegible]012	244	-0[illegible]	-0340395
00202	88892	93940	66[illegible]	6320800	23080	13613069	0003	0900700	7178	[illegible]008	404	-1[illegible]	1542535
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00227	88829	03502	88[illegible]	6248837	23080	14207736	0003	1337060	7200	[illegible]011	971	-0[illegible]	0781952
00255	88745	52246	83[illegible]	6802621	23080	14995137	0003	0912390	6944	[illegible]001	875	-1[illegible]	1731620
00255	88821	36316	27[illegible]	6896633	23080	14994933	0003	0912080	6944	[illegible]001	587	-1[illegible]	1732192
00255	88854	90965	87[illegible]	6019284	23080	14994985	0003	0912320	6944	[illegible]001	480	-1[illegible]	1731730
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00370	88742	87704	12[illegible]	6904784	23080	14660315	0003	2739860	7052	[illegible]007	491	-0[illegible]	-0589075
00370	88779	66504	33[illegible]	6857169	23080	14660356	0003	2739820	7052	[illegible]006	960	-0[illegible]	-0589081
00378	88779	95374	25[illegible]	6490064	23080	14288254	0003	2742230	7177	[illegible]016	689	-0[illegible]	-0568297
00378	88806	63746	29[illegible]	6396326	23080	14288366	0003	2743480	7177	[illegible]016	814	-0[illegible]	-0567555
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00398	88814	23601	41[illegible]	6590139	23080	14596317	0003	1619880	7077	[illegible]000	655	-0[illegible]	0250437
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00404	88794	06555	38[illegible]	6030753	23080	12734012	0000	1846900	7747	[illegible]020	474	-0[illegible]	-0113233
00404	88846	67866	35[illegible]	6205169	23080	12734125	0007	1846420	7747	[illegible]020	469	-0[illegible]	-0112602
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00426	88808	45665	88[illegible]	2900464	23080	13660591	0002	2235630	7393	[illegible]001	622	-0[illegible]	-0521550
00426	88841	39788	71[illegible]	6876312	23080	13660559	0018	2235540	7393	[illegible]001	692	-0[illegible]	-0521491
00426	88863	37008	86[illegible]	6875663	23080	13660503	0018	2235880	7393	[illegible]001	569	-0[illegible]	-0521694
00426	88904	35776	85[illegible]	6837791	23080	13660550	0006	2235710	7393	[illegible]001	593	-0[illegible]	-0521595
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00444	88843	81378	98[illegible]	9848896	23080	9648113	0133	5116119	8263	[illegible]838	811	-0[illegible]	-0252856
00444	88901	29130	96[illegible]	9868221	23080	9713113	1632	2198257	0838	[illegible]391	807	-0[illegible]	-0253136
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00502	88797	03259	20[illegible]	2312052	23080	11219134	6514	8048119	5452	[illegible]074	642	-0[illegible]	-0264957

Current Gear Ratio Elements Derived by NASA GSFC from NORAD Data as of 38897.9

NCAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
00502	88836	38641	18081	7297745	11272	13469	71305	50195	45407	46257	08578	1-0409274-	0265096
00502	88866	82077	16401	5287060	11313	13473	59506	41195	42907	46114	08610	2-0409698-	0264950
00502	88913	56647	13817	8270387	11376	13480	62007	26195	44907	45855	08572	7-0409750-	0265317
00503	88805	24220	52057	6168521	6758	77810	10000	01319	05107	57093	06108	-0456653	0433605
00503	88887	49362	49144	5196279	6822	77804	43000	01319	72107	57613	06970	-0456847	0433283
00504	88807	86323	37097	3420375	11016	12941	35401	72195	44207	66429	10512	4-0392537-	0254064
00504	88847	26933	35095	9407142	11067	12942	57101	27195	44507	66381	10503	0-0392539-	0254118
00504	88867	35671	34068	2400320	11093	12943	85702	58195	42907	66330	10494	5-0392680-	0253951
00504	88890	75279	33202	95387259	11145	12945	60902	44195	43807	66261	10482	6-0392657-	0254082
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00515	88895	19181	48232	6204373	6836	77902	20000	01319	35107	48613	04958	-0456801	0433524
00519	88837	59604	65144	1439799	12598	14537	24500	03251	84707	09321	00187	6 0015229-	0655884
00519	88898	79370	65266	2346118	12687	14537	32200	13251	83107	09319	00186	4 0015102-	0655896
00527	88851	16729	90611	2801661	12786	15251	44100	09227	47406	87001	00321	0-0197400-	0630071
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00564	88920	52379	68773	5385666	11640	15309	72402	65160	02306	85129	02233	4-0755329	0306604
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00573	88843	47734	38100	9688223	4653	63913	98000	01187	27122	64414	91772	-0457854	0528931
00573	88865	38145	37470	3695318	4667	63914	92001	11187	51122	64294	92496	-0458321	0529310
00573	88882	59217	36967	9701141	4678	63914	08000	01187	86122	64404	92249	-0458041	0528752
00573	88904	49166	36026	7708900	4692	63918	47000	01192	75122	63854	86099	-0452468	0519077
00574	88783	45722	44936	4800250	6225	86522	46000	02423	31100	23760	07985	-0031661-	0324880
00574	88834	31369	44797	6789436	6269	86524	79000	02424	07100	23580	07948	-0031349-	0324967
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00575	88227	48793	45449	8498963	4294	63979	23000	41187	30122	56074	92266	-0459063	0530306
00575	88793	79332	39211	7674698	4626	63980	52000	71187	59122	55914	91930	-0458763	0529766
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00575	88903	20312	36019	6713560	4696	63996	69000	01187	09122	53854	80280	-0450965	0521090
00580	88795	78234	33588	9077546	10969	16008	25220	93135	96206	64980	00055	63 -0981035	0863910
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00580	88868	18820	22190	0198109	11085	16040	72427	02136	00806	64082	00529	8-0983349	0865160
00580	88914	89584	14801	9250150	11160	16068	58830	92135	97206	63314	00463	4-0985857	0867987
00594	88780	83010	97858	2516683	9851	14445	41400	02250	03107	12323	00111	2 0000251-	0650800
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00602	88785	85556	74495	9723744	6241	86710	73000	02426	72100	09250	01505	-0030340-	0326116
00608	88873	00750	44774	1327503	6304	86525	74000	82426	18100	23510	03562	-0030479-	0325144
00612	88863	76530	20883	2727006	9558	14113	75300	14138	18807	23244	04396	0-0821885	0691677
00613	88821	48999	99118	1245209	10221	15214	23100	05228	69106	88121	00202	2-0186183-	0635260
00613	88890	43072	79678	3166126	10347	15214	46100	17228	70106	88114	00202	3-0186104-	0635327
00614	88729	44302	98804	9599485	7194	10893	48200	14228	10408	59721	18918	4-0135330-	0446997
00614	88883	22550	89730	9549406	7306	10893	69700	07228	19408	59709	18801	2-0134608-	0446830
00614	88887	33302	96499	7522757	7366	10893	67500	00228	16208	59711	18808	0-0134820-	0446722
00622	88785	67499	05294	1873293	5574	85792	34000	02458	54100	80550	04159	-0016927-	0323869
00622	88843	96620	05203	8866164	5624	85792	05000	02457	85100	80570	04629	-0017208-	0323832
00622	88866	13878	05158	3882084	5643	85790	74000	02459	02100	80670	04870	-0016729-	0323888
00622	88896	58873	05126	3997996	5669	85792	22000	02459	38100	80560	03436	-0016583-	0323909
00624	88871	22808	04486	2981405	5641	85897	10005	32448	76100	72360	75324	-0021188-	0000000
00630	88855	90569	05133	9024216	5643	85972	48000	02456	11006	64600	34437	-0017970-	0324638
00630	88887	36303	05069	4060770	5670	85973	47000	02455	58100	66390	03424	-0018187-	0324612
00682	88801	01263	15522	1676098	85691	60461	24286	62498	64061	47002	50509	-0001274-	0748655
00682	88841	49225	15512	0623707	86341	60677	89292	22498	28066	35500	01922	-0001619-	0749992
00682	88877	87738	61551	12526268	86941	60933	20379	22498	58066	28490	01632	-0001341-	0751578
00683	88924	12335	------	724743	78511	40775	15001	7------	07245	54052	99705	97-0656061	0209433
00694	88861	37582	12804	6465149	70261	33562	31000	10843	51075	01950	64689	-1027730	1621271
00714	88800	88124	08769	0478399	62071	24849	74003	42185	46078	50200	83336	-0215247-	0442469
00714	88888	10394	85550	7433517	63061	24858	75005	92185	13078	49820	83483	-0215507-	0442330
00733	88884	38342	02799	4844378	66941	42181	98000	02752	66071	98770	03105	0201474-	0557608
00733	88891	41758	03001	2801920	67941	42182	30000	12752	41071	98760	02780	0201281-	0557758
00734	88820	24765	27416	9949662	66631	42212	52000	02752	61071	97740	01509	0201486-	0557784
00734	88889	86994	29410	9905988	67621	42212	33000	02752	64071	97750	01601	0201512-	0557761
00735	88819	51493	27419	7960872	66591	42149	50000	27531	10719	98700	01498	0201763-	0557140
00735	88889	85436	29431	6892203	67591	42149	37000	02752	93071	99870	01590	0201622-	0557252
00737	88877	26979	02049	51681311	3413	73954	04000	01287	02111	27827	71766	-0416456	0417297
00737	88885	92391	21782	57708691	3477	73952	81000	01289	72111	27952	70802	-0415328	0414359
00737	88888	98483	16843	1714684	3499	73953	26000	01281	04111	27882	77542	-0420374	0425272
00738	88812	26664	19419	1692204	3441	73926	85000	01286	44111	30552	66894	-0414512	0415737
00740	88811	13216	06117	6786748	61171	32920	32010	82263	13075	29901	88818	-0172958-	0519105
00740	88847	25110	05280	6771608	61651	32924	47008	02262	95075	29130	19070	-0173101-	0519049
00740	88903	67961	03980	5741588	62411	32930	55006	02263	32075	28900	18644	-0172838-	0519247
00741	88871	21606	05306	7857760	61821	32221	69000	02264	27075	55780	13353	-0170824-	0515754
00744	88828	17262	98743	2250348	70521	55008	38035	70873	58067	92710	16233	-1222482	0098761
00744	88850	10588	94572	6314713	70871	55025	51040	70873	66067	92210	16324	-1222641	0099103
00744	88913	95866	82446	6503279	71861	55066	93060	87378	06791	00016	44441	-1223043	0100057
00746	88908	11470	27932	7212864	3966	85071	62000	21691	83101	36683	36658	-0394824	0073954
00759	88847	71027	49673	4730012	65681	52250	66000	32279	81068	77940	00825	-0192526-	0631670
00759	88918	62874	47608	2636513	66761	52252	90001	12279	87068	77880	00910	-0192483-	0631715
00771	88820	68559	04199	2556067	57191	43721	05010	71436	00071	45650	48310	-0809096	0601089
00771	88854	08404	00331	7586049	57671	43727	69011	14363	80714	54304	84448	-0808946	0600406
00771	88922	95905	92293	1644663	58661	43746	65013	81436	33071	44804	82402	-0809058	0600560
00775	88863	65486	96318	0613807	57971	44490	16015	11435	19071	20260	45709	-0814667	0606469
00775	88910	71388	90778	3655756	58651	44510	80020	31435	44071	19590	45886	-0814710	0606111
00784	88880	82366	54355	8436513	59951	56905	75007	01612	50067	40010	06218	-0769455	0290912
00784	88863	68379	36863	6664001	60821	56919	84014	01612	85067	39610	06636	-0769294	0290234
00784	88904	46394	31942	2678620	61461	56937	68021	21612	71067	39090	06400	-0769509	0290562

Current Gear Ratio Elements Derived by NASA GSFC from NORAD Data as of 38897.9

NCAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
00801	88851	38995	08092	11218	68	46801	39711	25000	22514	14072	83480	04859	0011060	-0622285
00811	88878	64690	71298	05350	83	51871	60365	82083	31941	70664	32200	00892	0632212	-0080529
00811	88919	82619	75464	16076	84	52541	60568	75258	63193	74066	37620	01159	0632911	-0081444
00812	88822	59785	06833	58769	72	45091	41774	35000	02771	65072	12540	00825	0215643	-0543208
00912	88892	42795	08966	48244	39	46081	41774	35000	02771	68072	12540	00963	0215667	-0543189
00813	88819	68813	06782	30219	52	45041	41750	69000	02771	64072	13340	00987	0215589	-0543095
00813	88889	53476	08915	79764	54	46031	41750	75000	02771	48072	13340	00942	0215464	-0543201
00824	88920	63633	05510	94382	42	47521	51842	98001	22282	00268	02400	01503	-0191504	-0629652
00829	88819	93622	79069	11086	97	2524	85649	47000	41689	46100	91033	31914	-0397346	0076808
00851	88831	03409	27358	13553	77	29581	13542	75005	12657	28083	63101	71175	0101488	-0489289
00851	88900	60830	28172	03167	87	30371	13554	68010	22659	01083	62511	71214	0102618	-0488834
00864	88785	59267	91234	39610	13	37061	51354	44413	13596	20690	30803	30368	-0913767	0804667
00864	88885	93482	17333	30824	18	30581	51615	41399	13596	80689	51602	95905	-0915644	0806235
00864	88909	67233	74039	31130	99	30941	51698	09599	13597	20689	26502	94209	-0916260	0806699
00866	88798	72205	83055	80261	61	37571	54309	03241	13597	80681	46702	21867	-0935627	0823839
00866	88891	90641	69548	61557	94	39011	54810	45309	81358	89067	09950	20371	-0940234	0829155
00867	88891	57365	76063	31094	056	38691	51729	84142	21359	98068	91690	29135	-0916281	0806310
00867	88921	87979	71855	71317	75	39151	51832	82162	71359	79068	88580	29091	-0917229	0807445
00872	88760	95734	12234	41198	47	35251	46452	58100	16274	09507	05820	02553	0200458	-0589000
00872	88844	25967	14675	70475	43	36471	46455	10001	42741	04070	58130	25268	0200524	-0588929
00876	88880	79282	97501	48560	761	35471	44701	58000	21807	26071	14290	13667	-0550602	-0072515
00876	88880	83996	86837	75307	74	36491	44701	47000	21807	59071	14290	13773	-0550357	-0073043
00878	88876	45080	01233	40115	879	35201	46433	43001	42740	88070	58790	25494	0200362	-0588944
00899	88880	37250	47594	87333	99	37981	37459	17000	02214	01073	62640	09371	-0217816	-0512044
00900	88754	71077	91692	32026	1	37171	35126	13000	24983	50744	12550	01334	-0001829	-0595398
00900	88838	31450	91665	31333	96	36981	35126	23000	24983	10744	12550	01861	-0001660	-0595402
00900	88908	60422	91644	05655	00	36981	35126	99000	24980	96744	12550	01661	-0001846	-0595404
00907	88918	38750	72495	65208	2	36981	37473	73100	02214	32071	59900	95979	-0217621	-0512343
00913	88807	36199	25914	65850	73	29751	58690	63000	13594	90668	86220	06360	-0369807	0854244
00913	88871	61644	91601	46622	92	30191	58777	03000	13596	00668	86220	06132	-0370420	0854592
00913	88891	06510	80999	87120	41	30191	58850	54000	13595	50668	41400	58870	-0371043	0855227
00922	88820	90209	87431	17878	28	23191	51662	50000	22790	20689	37100	07107	-0192221	-0627945
00922	88878	92518	85742	17325	64	28021	51664	49001	22790	90689	58650	00402	-0192167	-0627994
00924	88752	11613	03058	25877	54	24841	45144	16000	51443	46070	98802	56912	-0809595	0590101
00924	88858	86659	85817	27134	13	24411	45144	89000	31443	53070	98802	56780	-0809578	0589969
00925	88843	36384	86640	47653	35	27501	51812	01002	52278	90068	91180	00835	-0192579	-0628697
00931	88769	76309	74990	72740	00	19371	24272	18013	92260	96078	14579	06284	-0164238	-0487380
00931	88821	87310	78894	92421	43	20031	24292	22001	92260	76078	17373	09624	-0164408	-0487375
00931	88891	05767	72480	32008	84	20691	24320	83021	92260	81078	17373	62096	-0164447	-0487598
00933	88887	95183	72616	42021	88	20821	23877	11000	92260	55078	91328	09802	-0163978	-0485590
00947	88756	06279	00172	88936	2	21151	56903	07000	13542	90613	93301	09781	-0959183	0853502
00947	88806	40102	92581	95590	5	28121	56969	60000	13540	90673	74201	07751	-0959846	0854422
00947	88878	36702	81724	05113	9	23581	57065	58069	13541	30734	68010	41200	-0960366	0854994
00947	88922	28909	75100	71133	54	23991	57141	05900	13548	30673	22009	09967	-0960088	0853932
00948	88814	19819	08009	39016	380	22391	60591	52591	13540	50668	74003	11500	-0959748	0880487
00948	88858	34216	81049	21001	56	23111	61210	01000	13540	20668	74002	11500	-0959748	0885073
00948	88901	59712	74077	61708	1	23801	62603	72000	13540	00668	74000	00648	-0959748	0894370
00957	88750	76807	39487	62552	1	27271	55030	32000	10488	30673	29702	21974	-1134043	1524266
00957	88803	63716	90172	88390	2	20791	55172	70000	10490	70673	29702	21667	-1135248	1525511
00957	88858	58520	22444	67430	2	21301	55262	10000	10493	20673	88702	21379	-1135914	1526059
00957	88906	01148	12881	74301	67	22391	55446	81000	10492	20673	80302	20800	-1137654	1528539
00965	88841	38733	99853	69219	21	13781	35447	50000	24998	10743	57002	72722	-0000137	-0597301
00973	88819	62634	00049	61277	6	15161	47490	97000	02743	13070	25050	18297	0203914	-0592450
00973	88891	01392	60216	50551	352	16201	47491	83000	02742	95070	25050	18415	0203772	-0592577
00974	88881	33779	20071	88581	335	15211	51196	00000	27445	40690	98600	87621	0211761	-0610811
00974	88883	71796	70149	34555	186	15751	51271	02162	27442	60690	75700	89651	0211663	-0611408
00974	88886	75798	60243	89531	219	16031	51400	25237	12743	84069	03640	08687	-0211545	-0612363
00974	88888	80481	40311	16511	743	16341	51494	32215	92744	73069	00790	08635	0212483	-0612285
00974	88891	11362	40387	12483	235	16691	51629	73906	27443	90689	68008	28248	0212441	-0613218
00978	88817	41333	20748	22696	566	11501	20851	69000	48267	75308	02024	60936	15	0117402	-0494671
00978	88813	02421	08046	16734	56	11971	20851	31001	02678	62080	22470	93241	0118092	-0494160
00978	88841	15771	08433	26561	66	12311	20850	37000	02678	09080	22510	93543	0117765	-0494436
00978	88893	28703	09182	76243	17	12941	20851	50000	72678	70802	22460	92320	0118083	-0493865
00979	88784	26486	07630	56923	46	11611	20722	02000	02678	18080	28200	93947	0117678	-0493804
00979	88913	48669	09476	26150	74	13171	20723	37000	92678	94080	28140	93524	0118153	-0493405
00983	88907	85902	31419	21975	40	14711	47214	30006	51135	33707	03191	04336	8-0887883	0791472
00984	88746	68821	51672	20182	26	12381	48119	63172	31352	86070	03220	38722	-0894157	0797846
00984	88791	24110	45755	00743	79	13041	48199	89119	21352	78070	00690	39474	-0895069	0798774
00984	88829	69438	40675	31170	95	13611	48264	84098	31354	37069	98650	40723	-0894945	0796214
00984	88868	13080	35563	51609	55	14181	48332	60104	71352	00069	96510	39066	-0896532	0801294
00984	88897	78874	31626	41977	20	14621	48393	22101	21353	06069	94610	38788	-0896259	0799405
00987	88804	58438	59612	53389	200	13431	49285	01000	70912	39069	65440	03843	-1143682	1721444
00987	88903	45195	86272	05370	71	14291	49283	31000	00912	62069	65490	03986	-1143563	1720982
01001	88780	86549	05875	21052	00	747	99067	96000	00892	80091	56200	01656	-0667044	1018150
01085	88632	66541	51361	35904	77	8271	48434	66001	00881	83069	91950	11294	-1149417	1767811
01085	88896	07619	06343	23793	31	12181	48437	94000	50881	79069	91840	11855	-1149530	1768032
01088	88895	88903	06553	12850	55	12171	48346	25000	00881	76069	94730	11862	-1148577	1766612
01089	88768	79795	93228	43427	30	8861	37615	43021	55572	90735	58107	15563	-0694524	0347348
01089	88877	78746	21865	63949	04	10361	37645	19013	05576	70735	47507	14476	-0694450	0346749
01090	88769	72898	32504	93442	39	8851	37292	51022	91556	87073	67340	72589	-0692964	0347192
01090	88873	87444	22598	33940	49	10281	37324	87016	71556	98073	66180	72226	-0692981	0347039
01091	88803	45850	28331	43621	14	9381	38340	96021	61557	10073	30070	68976	-0698674	0349709
01091	88844	65897	24343	83819	83	9951	38355	60018	21557	16073	29550	68905	-0698708	0349634
01091	88917	65217	17292	94174	15	10961	38383	29018	51557	88073	28580	68865	-0698414	0348410
01097	88823	74567	18773	94126	53	9701	48793	95000	11806	40698	32600	42232	-0571737	-0073821
01098	88823	60229	18914	82423	7	9681	48654	73001	61807	11069	87620	09709	-0570656	-0074901
01098	88889	35630	11297	86245	474	10721	48654	70001	61807	28069	87620	09746	-0570531	-0075170
01228	88770	87972	92076	99560	363	6861	47366	48021	02499	46070	29120	36300	-0000448	-0671918
01228	88881	43260	72076	07517	983	7501	47377	80021	02499	46070	28760	36108	-0000448	-0671950
01228	88883	80756	72076	01495	206	7851	47380	05021	02499	46070	28690	36157	-0000448	-0671973

Current Gear Ratio Elements Derived by NASA GSFC from NCAT Data as of

NCAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
0122888850968072076544828 44					80414	7380210211	2499460702	8680363	49	-0000448	-0672012	
0122888881498892076134502 20					84914	7389530211	2499460702	8390361	92	-0000448	-0672040	
0122888920849802076094102 26					90714	7398740212	2499460702	8090360	02	-0000450	-0672116	
0124488862928371037892694 11					80013	9132900000	1946510730	3110015	11	-0422004	-0259589	
0124588796652531425333128 37					70913	9181440001	1947320730	1420017	10	-0421605	-0260724	
0124888773844622078615615 60					69014	7304870164	2499940703	1080356	11	-0000043	-0671409	
0124888837656642078425004 04					78414	7317430095	2499940703	0680359	39	-0000043	-0671548	
0124888891280422078394473 54					86314	7327840096	2499940703	0350359	06	-0000043	-0671606	
0124988736791572076145885 94					64114	9806122419	2499910695	2630299	50	-0000070	-0685669	
0124988786165292076555404 16					71514	9958721423	2499910694	7910298	19	-0000075	-0686581	
0124988820832302076775037 36					76715	0032841066	2499910694	5620298	26	-0000077	-0687036	
0124988837493432076744865 62					79215	0006795107	2499900694	4540297	16	-0000081	-0687233	
0124988887453222076014331 82					86715	0169880898	2499900694	1400296	45	-0000083	-0687846	
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0126788883891081526898272468					67913	7407490315	1556150736	3230719	66	-0693988	0348778	
0126788881111722486639292608					73713	7433780329	1556340736	2290719	40	-0694031	0348507	
0126888807127655548722559 52					63713	7705670251	1556840735	2600713	29	-0695341	0348428	
0126888866669439978562845 32					71913	7731190210	1556700735	1690710	74	-0695523	0348732	
0126888918214924484333093 20					79013	7753010203	1556790735	0910709	83	-0695588	0348625	
0126988807322685506062576 27					64013	8358750398	1556440732	9440688	76	-0699186	0350943	
0126988852129385072782792 19					70213	8386860328	1556280732	8460687	66	-0699446	0351319	
0126988886089624743642959 98					74913	8409810333	1556440732	7640686	83	-0699477	0351101	
0127188920456410702132605 00					80013	9130120000	1947060730	3210016	48	-0421589	-0260269	
0127288840589251116905272205					76913	9148630001	1946840730	2660016	45	-0421827	-0260041	
0127388801729739696891729 85					63414	7628580002	2750920702	0680118	46	0210490	-0587709	
0127388819340289750991558 78					66014	7628770002	2750660702	0670117	54	0210275	-0587872	
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Current Gear Ratio Elements Derived by NASA GSFC from NORAD Data as of 38897.9

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Recent Line 1 data — From W. P. Overbeck

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00579	89	04	94	55	85	43	50	18	29	42	50	6456
00580	88	96	71	19	33	06	52	34	32	03	68	11245
00580	88	97	64	35	07	05	04	16	33	64	97	11260
00580	89	02	29	38	97	97	60	79	40	66	73	11335
00594	89	03	13	83	72	97	85	82	21	82	37	10212
00602	88	94	73	00	09	44	53	34	16	75	57	6381
00602	89	01	42	38	02	44	35	69	19	11	81	6439
00608	88	95	04	63	83	44	56	19	32	52	55	6371
00608	89	01	97	98	20	44	37	79	29	81	20	6431
00613	88	95	16	35	95	95	43	45	12	85	83	10419
00613	89	04	01	01	45	59	29	06	20	28	48	10555
00614	88	96	62	77	26	95	33	84	84	33	3	7452
00624	89	01	32	51	72	04	22	61	94	61	47	5765
00630	88	97	68	62	48	04	94	08	98	17	44	5747
00669	88	95	12	93	95	02	04	08	80	72	66	7991
00670	88	95	13	26	13	01	99	08	83	93	11	7971
00682	88	97	79	14	26	15	49	27	39	41	58	8854
00682	88	98	40	72	95	15	48	66	37	07	73	8864
00682	89	01	11	93	18	15	48	26	40	20	57	8907
00682	89	02	34	42	33	15	47	96	38	92	83	8927
00683	89	00	72	33	13	28	23	27	49	68	3	7967
00694	89	03	65	97	41	98	12	22	82	95	27	7250
00704	88	96	74	52	88	27	74	97	36	21	11	7096
00705	88	96	34	59	82	27	75	15	33	12	13	7092

CAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
00004	88	96	84	48	89	91	34	65	89	47	-1042258	1558035
00005	88	96	46	61	88	45	27	54	20	56	-0780914	1141900
00005	88	97	39	66	70	44	49	43	21	70	-0781042	1142184
00012	89	01	45	11	35	90	06	85	51	70	-0824723	1239873
00016	88	98	63	79	73	74	83	46	30	61	-0759064	1109445
00020	88	96	33	44	76	78	91	88	81	99	-0822536	1225722
00020	89	04	08	82	99	71	83	24	30	54	-0822716	1226285
00022	88	97	04	24	60	64	85	27	21	76	-0817673	0664806
00023	88	99	84	04	83	51	74	56	32	55	-0820221	0667235
00031	89	01	42	90	60	91	64	36	48	73	-0886036	0679562
00043	89	00	09	78	07	14	62	46	18	87	-1176402	1763918
00045	88	97	13	90	79	56	91	50	87	04	-0502824	-0138537
00047	89	04	64	77	01	43	53	20	86	35	-0504701	-0137996
00049	89	00	29	58	73	90	85	13	02	64	-0746849	0715068
00050	88	99	78	55	63	71	18	94	16	76	-0705731	0677883
00051	89	01	94	13	21	74	08	62	16	15	-0704361	0676744
00058	89	03	93	35	32	50	24	48	72	59	-1043842	1704779
00060	88	96	60	96	83	47	37	47	83	10	-0735212	0610217
00062	88	95	81	90	28	39	46	80	89	65	-0739207	0615578
00062	88	99	77	88	61	35	69	07	92	70	-0739268	0615979
00063	88	96	35	65	02	26	33	65	62	61	-0879750	0792526
00064	88	99	22	46	04	17	11	49	69	73	-0881321	0793772
00070	89	33	00	46	66	00	02	09	27	77	93	23874
00079	89	01	44	77	03	64	92	34	02	64	83	23877
00099	88	98	43	93	53	72	63	54	12	61	65	27591
00107	88	96	69	28	57	10	58	98	43	94	60	19739
00163	88	96	95	00	85	78	43	47	16	62	22	12523
00165	88	97	89	66	84	47	66	21	02	32	59	20167
00192	88	96	66	18	12	58	47	48	28	75	98	11307
00196	89	01	00	67	47	78	45	20	20	27	64	12528
00202	89	03	42	94	14	73	15	93	64	86	45	17486
00205	89	05	22	61	34	71	52	66	67	12	10	17506
00226	88	94	00	82	06	94	52	52	43	65	37	17080
00227	88	93	23	20	40	24	12	44	29	50	23	16903
00227	88	99	91	86	18	16	04	62	37	05	94	16998
00255	88	98	95	44	23	85	01	29	63	96	48	17515
00257	88	96	25	33	24	43	44	72	25	31	0	17468
00271	88	96	90	84	33	89	06	84	94	30	11	10667
00285	88	04	58	98	13	46	22	51	90	12	84	16079
00288	88	99	91	27	29	49	51	18	89	03	51	16021
00309	89	01	92	31	04	55	23	46	91	25	54	15298
00311	88	94	79	96	39	60	29	05	89	41	38	15208
00341	88	95	02	89	35	18	57	24	95	61	90	9498
00370	88	97	11	94	12	46	75	01	27	56	02	14621
00378	89	02	07	05	66	32	49	92	28	94	30	14323
00424	89	01	40	82	91	82	64	46	79	45	58	13177
00426	89	00	39	27	22	82	67	58	78	38	94	13170
00444	88	98	42	80	05	93	25	15	84	16	4	9807
00444	89	02	39	53	62	91	76	41	83	24	32	9852
00444	89	05	39	05	05	90	64	72	82	40	1	9886
00502	88	99	51	30	95	09	31	34	24	13	38	11485
00503	88	94	78	97	69	46	98	12	21	67	75	6869
00503	89	03	40	04	32	43	92	65	24	55	98	6936
00504	88	96	70	02	06	28	99	79	36	76	66	11222
00504	89	01	64	25	38	26	48	51	35	13	58	11286
00506	88	96	23	51	57	04	86	17	82	37	36	12164
00515	88	98	37	64	37	45	08	01	23	40	22	6905
00519	88	95	03	98	77	65	37	83	16	45	0	12761
00519	89	04	05	06	51	65	57	68	22	29	81	12892
00527	88	96	32	86	25	87	24	17	69	73	37	12958
00564	89	00	73	86	00	58	73	45	42	65	16	11773
00573	88	97	33	23	14	34	26	28	73	16	07	4736
00573	89	01	40	03	29	33	13	99	74	45	94	4762
00573	89	03	43	58	53	32	50	15	75	25	37	4774
00574	89	01	93	87	66	44	34	38	73	90	1	6429
00575	88	99	38	56	22	33	39	19	74	21	86	4754
00575	89	03	29	30	51	32	23	60	75	55	11	4778
00579	89	04	94	55	85	43	50	18	29	42	50	6456
00580	88	96	71	19	33	06	52	34	32	03	68	11245
00580	88	97	64	35	07	05	04	16	33	64	97	11260
00580	89	02	29	38	97	97	60	79	40	66	73	11335
00594	89	03	13	83	72	97	85	82	21	82	37	10212
00602	88	94	73	00	09	44	53	34	16	75	57	6381
00602	89	01	42	38	02	44	35	69	19	11	81	6439
00608	88	95	04	63	83	44	56	19	32	52	55	6371
00608	89	01	97	98	20	44	37	79	29	81	20	6431
00613	88	95	16	35	95	95	43	45	12	85	83	10419
00613	89	04	01	01	45	59	29	06	20	28	48	10555
00614	88	96	62	77	26	95	33	84	84	33	3	7452
00624	89	01	32	51	72	04	22	61	94	61	47	5765
00630	88	97	68	62	48	04	94	08	98	17	44	5747
00669	88	95	12	93	95	02	04	08	80	72	66	7991
00670	88	95	13	26	13	01	99	08	83	93	11	7971
00682	88	97	79	14	26	15	49	27	39	41	58	8854
00682	88	98	40	72	95	15	48	66	37	07	73	8864
00682	89	01	11	93	18	15	48	26	40	20	57	8907
00682	89	02	34	42	33	15	47	96	38	92	83	8927
00683	89	00	72	33	13	28	23	27	49	68	3	7967
00694	89	03	65	97	41	98	12	22	82	95	27	7250
00704	88	96	74	52	88	27	74	97	36	21	11	7096
00705	88	96	34	59	82	27	75	15	33	12	13	7092

NCAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
00	7	14	89	01	38	3391	82	1584	3634	73	-0215704	-0442403
00	7	16	89	01	42	1430	25	2042	8880	12	-0683050	0237912
00	7	33	89	02	59	9931	33	2169	7061	17	-0557732	
00	7	34	88	95	94	8333	34	1041	8499	98	-0557728	
00	7	34	89	02	98	3483	33	4342	8433	99	-0557813	
00	7	35	88	96	02	3368	31	4512	8807	93	-0557307	
00	7	35	89	02	98	8337	33	4411	8326	86	-0557457	
00	7	37	88	96	20	0079	14	3907	3418	8	0438810	
00	7	37	89	00	12	1639	13	8827	4876	5	0424997	
00	7	38	88	97	72	9501	14	3976	7421	02	0413432	
00	7	38	89	00	16	4349	13	6783	7491	55	-0413739	0411898
00	7	40	88	96	61	2475	02	5461	7085	61	-0172751	-0519298
00	7	40	89	04	36	1180	00	7685	6649	25	-0172464	-0519469
00	7	41	89	00	13	0381	02	3653	7738	78	-0176806	-0515752
00	7	44	88	98	93	7616	81	2557	2149	72	-1223480	1892227
00	7	44	89	04	09	6810	58	3055	8747	10	-1224015	1893425
00	7	46	89	01	39	0768	24	3856	2192	08	4056	0073160
00	7	59	88	96	78	7601	46	1599	5698	13	-0192583	-0631652
00	7	59	89	05	12	7245	43	7229	4650	37	-0192390	-0631803
00	7	71	89	01	96	4706	81	0341	7281	55	-0809868	0602000
00	7	75	88	97	22	9452	85	2277	0929	3	-0814833	0606090
00	7	75	89	01	93	3583	77	9856	7497	79	-0815240	0606961
00	7	84	88	96	62	7011	24	4699	7107	05	-0769363	0289744
00	7	84	89	03	12	4539	16	6256	7369	83	-0769646	0290019
00	8	01	89	00	81	4906	08	3278	9960	00	4899	0622292
00	8	11	88	95	77	8834	79	3318	5915	98	-0081637	
00	8	11	88	97	76	1626	81	3512	4763	97	0634234	-0082451
00	8	11	89	03	07	9978	67	7344	6942	5	0636857	-0081907
00	8	11	89	04	83	4661	88	6118	4721	26	0638343	-0081381
00	8	12	88	96	22	8565	11	0995	8115	01	0215598	-0543249
00	8	12	89	03	00	0986	13	1551	7752	22	0215306	-0543500
00	8	13	88	95	93	4086	11	0503	7380	2	0215500	-0543173
00	8	13	89	02	98	6373	13	2093	7864	13	0215510	-0543165
00	8	29	88	95	77	0612	74	3845	1170	67	-0396884	0076174
00	8	51	88	97	72	1850	29	0523	7389	2	0101935	-0489511
00	8	51	89	02	12	4161	29	5560	2495	59	0101958	-0489681
00	8	64	89	01	04	2817	60	0002	2360	15	-0918736	0809283
00	8	64	89	05	11	9739	54	3122	2851	66	-0919379	0809036
00	8	66	88	95	38	3920	60	4912	2354	58	-0943966	0834364
00	8	66	88	98	92	5661	55	3148	2817	75	-0945516	0835476
00	8	66	89	02	01	2710	50	7885	3201	09	-0946165	0834510
00	8	67	88	97	58	5775	64	3286	1974	26	-0918383	0808441
00	8	67	89	02	05	7454	58	0783	2526	00	-0919721	0810232
00	8	70	88	98	52	3208	90	8496	6422	69	-0215610	-0521511
00	8	71	89	00	39	5074	88	4850	6457	90	-0215909	-0521823
00	8	72	88	97	80	8996	18	6042	9360	87	0200775	-0588766
00	8	76	89	00	76	5282	59	1289	5440	78	-0549829	-0074196
00	8	78	88	94	82	0837	17	7323	9606	22	0200761	-0588651
00	8	93	88	98	77	5335	91	6353	1121	83	-0001691	-0597269
00	8	97	88	97	85	1549	16	3310	5203	0	-0001568	-0595246
00	8	97	89	01	85	8142	91	6301	0413	49	-0001521	-0595246
00	8	99	88	97	75	9150	70	7386	6070	45	0217702	-0512134
00	9	00	88	99	15	1448	91	6259	0235	68	-0001586	-0595403
00	9	13	88	99	43	3344	97	0753	8201	77	0971704	0854373
00	9	13	89	03	39	9501	79	0943	1887	690	-0972718	0855917
00	9	22	88	97	78	7318	28	2860	1707	888	-0192160	-0628007
00	9	24	89	02	83	9181	70	6011	8235	25	-0809394	0589192
00	9	25	88	96	78	5678	83	0055	6464	99	-0192578	-0628747
00	9	31	88	98	75	6813	70	5027	1430	72	-0164678	-0487634
00	9	31	89	03	09	8837	69	6103	1174	45	-0164773	-0487603
00	9	33	88	96	78	6925	70	9809	1541	89	-0164227	-0485401
00	9	33	89	00	41	9511	70	2347	1320	39	-0164368	-0485289
00	9	47	88	95	21	9500	70	5855	1535	59	-0961443	0855643
00	9	47	89	02	97	8044	58	8504	2577	23	-0962287	0855932
00	9	56	89	03	84	9626	39	9815	3076	12	0114999	-0597440
00	9	57	88	94	39	6073	05	3586	5233	37	-1138523	1530092
00	9	57	88	98	95	5469	73	8176	2746	4	-1139518	1531375
00	9	57	89	03	64	8290	88	9215	7385	68	-1140755	1532861
00	9	73	88	96	06	5154	04	2831	4893	6	0203759	-0592603
00	9	73	89	02	91	2817	06	3375	4275	53	0203663	-0592661
00	9	74	88	98	29	2522	06	1868	4015	86	0213240	-0615572
00	9	74	89	02	10	4636	07	4134	3912	61	0214028	-0617028
00	9	74	89	03	08	6126	07	7646	3466	02	0214551	-0617691
00	9	78	88	96	36	2196	10	1965	5825	93	0118492	-0493785
00	9	78	89	04	38	8545	11	3784	5343	28	0119963	-0492685
00	9	79	88	98	05	8238	10	4371	5745	20	0117813	-0493591
00	9	83	88	98	86	6450	20	8430	2918	08	-0888637	0792058
00	9	84	89	01	22	5934	16	3786	3339	72	-0897340	0798685
00	9	84	89	02	23	5246	15	0294	3470	60	-0897504	0798877
00	9	87	88	99	52	2936	70	5898	7802	09	-1143557	1721023
01	0	00	88	97	45	6750	93	3394	5039	18	-0665451	1015765
01	0	02	88	95	38	7383	94	7750	4973	98	-0665158	1015885
01	0	85	88	99	71	3193	89	0619	5500	74	-1149358	1767326
01	0	88	89	00	71	0690	87	5731	5652	77	-1148563	1766549
01	0	89	88	98	09	4139	11	9987	4440	63	-0694463	0346445
01	0	90	88	95	10	5726	15	2501	4309	04	-0693103	0347121
01	0	90	89	05	29	8012	05	5434	4798	72	-0693067	0346772
01	0	91	88	96	67	8890	12	5463	4411	77	-0698590	0348776
01	0	91	89	02	74	7976	06	6649	4706	05	-0698364	0348771
01	0	92	88	96	78	8517	15	4606	4331	39	-0683560	0340881
01	0	94	88	79	67	3327	27	8257	3651	76	-0710821	0357101

Current Gear Ratio Elements Derived by NASA GSFC from NORAD Data as of 38911.9

NCAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
01097	88960	85198	07108	6403796	11741	48794	44000	21806	26069	83250	04135	-0571845	-0073591
01098	88953	43421	07894	5239515	11611	48654	58001	61807	13069	87630	09567	-0570638	-0074925
01098	88981	68596	05099	2337933	12031	48655	19001	61807	44069	87610	09655	-0570404	-0075433
01099	89018	75616	39957	5312455	21663	13545	53600	09249	93507	43519	00388	-0000488	-0597363
01208	89031	02498	00516	1202971	10341	39150	46000	21946	94073	02500	01702	-0421761	-0260168
01228	89000	90191	20768	6330990	10251	47418	60213	24994	60702	74803	64970	-0000450	-0672275
01228	89053	81135	20760	7279228	11031	47434	87021	32499	46070	26940	36463	-0000452	-0672370
01244	88955	65464	04937	1250619	9291	39134	81000	01947	01073	03050	01300	-0421643	-0260221
01244	89042	63326	99840	2236111	10501	39134	78000	51947	66073	03050	02017	-0421170	-0261031
01248	88967	29615	20784	6371186	9751	47343	79009	72499	94070	29840	36070	-0000043	-0671735
01248	89020	90836	20776	1317382	10541	47360	76014	32499	94070	29300	36120	-0000045	-0671848
01249	88965	98037	20765	7350908	9851	03576	51212	24999	00693	56202	90870	-0000083	-0688903
01249	88993	90352	20757	8322719	10271	50466	66173	42499	90069	33402	89870	-0000083	-0689541
01249	89043	71905	20758	7272040	11021	50665	22182	24999	00692	61802	79120	-0000086	-0690594
01250	89053	64876	20778	1285647	11021	47295	49011	32499	57070	31380	36446	-0000362	-0671514
01267	88953	86910	41722	0327554	8371	37473	54026	51556	37073	60870	71692	-0694196	0348553
01267	89020	05676	35404	4359540	9281	37504	13023	61556	52073	59780	71535	-0694247	0348349
01268	88966	85018	40182	2332627	8571	37767	38014	61556	93073	50400	70939	-0695568	0348405
01268	89043	78450	32807	9369633	9631	37791	63015	57000	73495	40707	72200	-0695607	0348317
01269	88953	99401	40862	8328838	8421	38449	08022	91556	55073	26250	68542	-0699615	0350999
01269	89019	71503	34495	8360872	9341	38481	33025	31556	71073	25120	68302	-0699651	0350787
01272	88973	53761	03883	2220002	9541	39147	87000	11946	97073	02560	01706	-0421730	-0260205
01273	88957	52759	01801	3040544	8641	47629	25000	22750	69070	20266	01866	0210307	-0587859
01288	88991	34321	03299	3026845	9171	48481	91085	27550	60699	37600	95555	0215540	-0589381
01288	89001	45306	03619	8033451	9321	48515	24126	27555	00699	27100	94115	0215969	-0589258
01288	89023	65273	04316	1986539	9651	48551	77092	32754	56069	91570	09455	0215252	-0590082
01289	89031	47760	04087	3978985	9731	47606	06005	27507	90702	13901	16778	0210340	-0587662
01290	88993	48347	02912	8982008	9181	48303	30012	27502	75040	06999	38012	32400	0211349	-0591662
01290	89043	35811	04494	4937747	9921	48449	26162	27509	60699	47901	20640	0212094	-0592054
01292	88957	07849	04852	4230311	9331	39134	22000	71946	99073	03070	01466	-0421657	-0260194
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01313	88966	96692	09908	1607317	13721	19623	52000	02678	82080	77260	96038	0116776	-0488028
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01355	88979	13482	40154	8337027	7951	37028	10059	91559	05073	76820	72443	-0689688	0342328
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01356	88964	19256	39089	9342520	8651	41791	87479	41561	08072	10660	61321	-0716970	0352749
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NCAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
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01357	88994	11012	64367	61527	61	31015	13490	90000	26454	50690	52700	20830	0126407	-0663701
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01359	88967	24905	63445	86412	59	94	91709	06000	00891	67096	39810	47837	-0605032	0924233
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01361	89005	61591	59893	87210	07	138	98917	16000	00892	09091	65500	01216	-0665871	1016860
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Recent Line 1 data: From W. P. Overbeck

00047 38900.071549 .467814 .877352 025463 14.203126 0.73

00192 38904.151155 .589205 .251543 011372 08.676940 0.00

00257 38908.055584 .239558 .566303 017646 15.000178 9.50

Improved Two-Line Set For Pegasus I:

01085 38886.037377 .124566 .189567 001164 14.843808 10.8

.088166 06992.10 0113.87 -1.151032 +1.768327 00 351 14.843793

Two Line Set For Pegasus II:

01381 38910.113701 .357017 .247154 000071 14.821783 10.2

.088191 06999.01 0116.66 -1.151032 +1.768327 00 351 14.821783

Current Gear Ratio Elements Derived by NASA GSFC from NORAD Data as of 38925.9

EXHIBIT E

NCAT	JNP	AJNE	AQNP	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
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00005891	50757112	96193434361			28312107	47419000030	95116	08672331	6503	-0781478		1142396
00011890	67498851	37178756378			26274114	80898000109	12900	82986013	6419	-0850889		1280271
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00049891	21276397	96363157053			21840126	81125009413	13220	77672504	5837	-0747920		0717420
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00503891	71518483	90453291658			7044	77809030000	13173	11075719	3055 44	-0456891		0435160
00504890	66611042	39373335118			11351129	53427028919	54800	76595210	5016	-0392748		-0254818
00504891	36082142	03952311916			11441129	56746024819	54620	76582210	4534	-0392877		-0254605
00506891	71801868	30375973100			12453137	97763200014	45630	73426802	1938	-0754789		0547060
00509890	74333246	56954186225			12940145	36199000325	18580	70935500	1846	0015321		-0655814
00515891	22400014	01423281028			7014	77902230001	13194	91074861	304590	-0456565		0433189
00519891	68457956	58541108275			13078145	37333000025	18350	70931900	2190	0015135		-0655899
00533890	74312272	30710878596			12199147	43819001027	90950	70266801	4870	0243384		-0558789
00534890	74081582	31056882176			12199147	41830000427	91070	70272310	14900	0243445		-0558597
00564890	86390724	95982462869			11894153	17207021916	00550	68490602	1895	-0755513		0306119
00564891	45145764	27994490699			11984153	18800015116	00780	68485802	1842	-0755440		0305702
00573891	39186852	94301788030			4841	63913850000	11876	81226443	492503	-0458264		0529132
00574891	07243704	41206866691			6505	86525330000	24273	81002354	002441	-0029981		-0325251
00580890	56953589	21361461110			11390161	94171718813	59450	65988800	02672	-0996272		0877618
00580890	86553528	73514499645			11438162	40098921313	59330	65864350	02325	-1000122		0881220
00580891	09305838	36428537552			11475162	91681	13513	59310657	244001	818-1004367		0885000
00602891	39954364	40231165232			6548	86710670000	24262	21000926	002037	-0030548		-0326068
00602891	74530014	39372136154			6578	86710720000	24262	81000925	001535	-0030522		-0326074
00603891	63705119	78542108258			10404144	46425000225	00340	71229000	1694	0000280		-0650864
00608891	09946994	41438274992			6508	86525870000	24259	91002350	003408	-0030556		-0325124
00608891	73507164	39807253102			6563	86525180000	24258	61002356	003132	-0030610		-0325107
00612890	84112319	53064942166			9868141	14464800171	38140	79072321	90440	32-0822202		0692518
00613891	68551728	92981952996			10749152	15115190011	22867	60688095	001991	-0186333		-0635219
00622891	55374430	47327943526			5891	85792000000	24590	81008057	003218	-0016707		-0323890
00624890	71455190	41194932026			5815	85909930001	24496	61007136	079715	-0020851		-0328021
00624891	51776780	39726913194			5884	85910650006	24493	91007130	081684	-0020974		-0328215
00630891	05982170	47413955070			5858	85974020001	24565	31006634	003246	-0017796		-0324668
00670890	78064470	19499741052			8141131	41360800002	49745	07483840	02937	-0001886		-0589602

Current Gear Ratio Elements Derived by NASA GSFC from Nimbus-III Telemetry

NCAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
00683891457424320011979	1244				8162140789680033163697072450405293				0-0656307			0210887
00683891755743117255480	0101				8204140789930033163696072450305293				0-0656308			0210889
00694891758581778963013	3317				7436133564070003084318075018806509				1-1028066			1622146
00714890778893680436132	8357				6543124900470130218552078480808408				4-0215413			0442937
00714891603489078213728	3062				6646124919150108218533078473008408				4-0215623			0442973
00721890831190980585932	0276				6533124298260001218372078734009036				1-0215976			0440405
00727891681815732400320	2562				7113139201630001194232073007000107				2-0425344			0254520
00728890790669137690521	6051				6988139202910001194222073006600117				2-0425422			0254400
00731890844465137408819	7710				6995139192260000194218073010300106				2-0425410			0254318
00733891736962637454158	7537				7164142181960000275255071987700264			0	0201383			0557671
00734891001519135448778	7617				7061142212990001275256071977300113			7	0201444			0557817
00734891542704136997970	7962				7138142212690000275252071977400121			0	0201417			0557836
00735891002466035457979	8162				7058142149860000275254071998600126			3	0201317			0557494
00735891537033337002474	5666				7134142149260000275296071998800094			2	0201642			0557231
00737890580080011637476	6366				3623 7395281000012800311127932770			29	-0420440			0426014
00737890985725410427977	8316				3653 7395343000012814411127872723			08	-0418187			0422788
00738890584570111868576	8417				3622 7392591000012868011130642645			74	-0413533			0414517
00738891477353509133779	5940				3688 7392587000012864911130652646			70	-0413653			0414848
00741891729848398477065	6862				6582132221880000226416075557701293			7	-0170897			0515677
00744891511576937340219	7669				7540155219170304087388067865601559			1	-1224451			1893439
00759891773536940032831	2962				7070152259600010227985068776700107			7	-0192509			0631742
00771890780642474209577	7928				6088143802500190143583071429504818			0	-0809783			0601853
00771891573332564987846	6640				6202143826120148143603071421704824			1	-0809855			0601615
00775890684440571219447	9354				6092144593370294143530071168704533			2	-0815265			0606737
00775891500403562564586	4223				6210144632660227143509071155805458			7	-0815771			0607433
00784891121293506848077	4082				6471157034230237161258067363300691			7	-0770269			0291088
00784891611623300911379	8661				6548157049780169161305067358900658			0	-0769989			0290153
00811890805661791946582	0276				5513161975687588319383065991400088			1	0640391			-0082231
00811891273038596830953	9583				558816341068 6783193560656048000595				0647725			-0083706
00812890984409515249774	0593				4900141774950001277137072125200074			4	0215423			-0543400
00812891485203116771370	2011				4971141774950003277135072125200065			8	0215405			-0543415
00812891696938917426570	4415				5001141774960001277139072125200089			1	0215441			-0543384
00813890997739215341883	1190				4901614175123000027716707213330008			27	0215608			-0543081
00813891512724716921179	1527				4974141750830000277128072133400041			9	0215305			-0543336
00813891695983917472175	4390				5000141751200000277153072133300104			1	0215496			-0543177
00824891833966997881317	9097				5150151849830013228021068900401575				-0191508			-0629695
00829890779600370299012	4966				2747 8565308000816903010090753314			02	-0396933			0075890
00829891818672566767913	1621				2836 8565361000316905410090713309			85	-0396590			0075582
00851890775843730200821	8215				3237113597230119265775083604317			17	0101917			-0489746
00851891638470331207517	0149				3335113614630094265790083595717			1169	0101977			-0489542
00864890840549849709432	7057				4160152217011205135998068769802772			6	-0919907			0809494
00864891339667842717538	7045				4236152312150927136009068741102742			6	-0920538			0809871
00864891740095737105743	6583				4297152370690810135999068723502713			5	-0921015			0810452
00866890804937541877440	0018				4195155864952473135882067692401808			4	-0948484			0836550
00866891266613935037744	3622				4267156011731953135901067649901823			4	-0949572			0837203
00866891465397332119148	2554				4298156054221886135906067637601787			3	-0949830			0837351
00866891715253128409351	4165				4337156132591892135873067615001756			5	-0950644			0838605
00867891177726144624371	8845				4214152370370935135939068723602749			0	-0921493			0811848
00867891637040938022842	8859				4284152435250718135951068704102673			7	-0921781			0811909
00872890743600521421285	1504				3984146464250030274106070578302512			8	0200553			-0588947
00872891590204323894077	7898				4108146466897002427407307057680250			18	0200290			-0589159
00876891396494648616353	1893				4027144702400001180790071142601402			1	-0550146			-0073530
00877891774087194649466	1025				4074144603840000180858071175000681			3	-0548817			-0074479
00878890683944021246185	8284				3975146443460024274104070585002498			3	0200498			-0588826
00878891708195324243176	7021				4125146447650019274077070585370250			92	0200283			-0589033
00900890714513191601097	5376				3140135127120004249762074472200176			5	-0001778			-0595404
00902891394937991583690	4544				3231135083030000249775074488400159			7	-0001682			-0595144
00907891620600465192547	5022				3271137477350000221423073619900927			7	-0217684			-0512272
00913891130923678681998	3507				3456159275521083135945066722400513			0	-0974544			0858480
00913891614290471117540	7756				3533159361450952135955066698400508			0	-0975173			0858863
00922890682021880229962	1845				3089151669060001422791306895510006			10	-0192141			-0628043
00922891538416677732945	7576				3219151671070014227905068954500066			8	-0192212			-0628009
00925890679726480079755	0908				3091151828130041227903068906900060			0	-0192492			-0628865
00925891581522677446838	5730				3228151833680027227905068905200079			9	-0192485			-0628906
00931891210278367762806	4016				2375124401940120226027078691009607			7	-0164920			-0487666
00931891403204767366405	2079				2399124397860000226008078692709551			9	-0164985			-0487376
00931891684555066795303	5797				2434124403890066226006078690209545			7	-0165009			-0487375
00932890836367268622208	3490				2325123908650002226024078899609810			4	-0164256			-0485619
00932891385160467499305	0862				2393123908920003225992078899509821			3	-0164486			-0485491
00933890881487368520808	2213				2330123878830005225990078912309876			0	-0164446			-0485335
00933891777525866965028	2977				2441123878620000225972078912409806			0	-0164547			-0485179
00947891282691343920939	0136				2719157437440681135392067240700971			9	-0963693			0858138
00947891574884739504843	2216				2765157456680509135535067235200924			8	-0962822			0854984
00953890832885439985434	3730				2260135853730001249960742065002460				-0000229			-0599687
00957890627934284239080	0562				2481155872381838104920067680801988			4	-1141644			1533931
00957890974246178055888	2635				2535155988911799104880067647001982			7	-1142996			1536328
00957891108873775675491	6331				2556156021931599104896067637501908			1	-1143085			1536213
00957891518922168338601	5338				2620156138761450104876067603701843			7	-1144220			1538035
00957891807047363189208	5368				2665156226061474104894067578501857			2	-1144996			1538806
00959891347206639972524	6007				2322135449380001249976074354000314			2	-0000182			-0597318
00965891591068939965822	2634				2355135447900001249950074354600036			8	-0000371			-0597312
00973890982844608416236	7934				1927147493610005274288070249701826			6	0203709			-0592618
00973891511656110006931	8531				2005147493990000274263070249501863			7	0203518			-0592809
00973891694746610550230	7027				2032147494560006274283070249401806			8	0203666			-0592637
00974890767018709251134	3842				1921153067566070274474068534400620			7	0215402			-0620677
00974891282155410965328	9302				2000153631285510274493068366700576			3	0216626			-0623581
00974891730515812420124	7019				2068154202797355274497068197800474			7	0217727			-0626618
00978891911845512453348	9050				1567120850500002682040802251091762				0120238			-0492458
00978891688344013119146	0298				1627120848420000267940080226009208			2	0118520			-0493522
00983890911200407425641	1395				1742147440600581135381070247104239			8	-0889133			0791908
00983891406293800938346	8499				1815147462550084135348070240104255			4	-0889570			0792802

Current Gear Ratio Elements Derived by NASA GSFC from NORAD Data as of 38925.9

NCAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
00983	89170466	19970265	505009		18591	4748591	0364	1353890	702327	042469	-0889472	0792090
00984	89091620	80057	816430027		17511	4875433	0795	1354430	698329	037845	-0898037	0798869
00984	89130605	35005	6864755555		18091	4880043	0649	1354240	698184	037848	-0898537	0799616
00984	89180327	86939	122535489		18831	4886152	0681	1353930	697993	037586	-0899157	0800649
00987	89084331	08553	448020062		16981	4927841	0000	0912430	696965	003925	-1143601	1721274
00988	89054663	78609	088935193		16521	4914165	0002	0912670	696991	003923	-1142092	1718710
01001	89065518	57870	645392319		1030	9906796	0000	0892800	915620	001656	-0667044	1018153
01002	89146044	96821	192618375		1107	9883301	0002	0892380	917070	000996	-0665041	1015391
01085	89160836	58611	082981974		16101	4844012	0004	0882030	699178	011214	-1149378	1767514
01088	89104855	71708	919829155		15261	4834768	0004	0881900	699468	011404	-1148501	1766323
01089	89164691	94944	160532175		14311	3770237	0075	1557920	735272	071039	-0694515	0346403
01090	89162162	29514	395323334		14241	3739658	0101	1556860	736362	071842	-0693410	0347439
01091	89115611	10981	366513372		13701	3844291	0146	1557510	732647	068497	-0698932	0349227
01091	89164727	55933	895537161		14381	3845274	0114	1557890	732613	068319	-0698686	0348534
01092	89091602	00039	908490611		13131	3580260	0066	1558590	742113	076818	-0683248	0339813
01092	89174073	85963	409529904		14251	3580980	0048	1558670	742087	076629	-0683171	0339651
01097	89148360	14911	593385796		14531	4879544	0003	1806440	698321	004101	-0571711	-0073885
01098	89061739	03987	238226795		13221	4865557	0016	1807380	698760	008719	-0570410	-0075334
01098	89144480	91916	906217800		14451	4865624	0016	1807290	698757	009375	-0570510	-0075193
01099	89083709	39397	00243707		22531	3545599	0013	2499340	743516	006966	-0000492	-0597440
01099	89168635	46399	546210506		23681	3545554	0002	2498890	743518	003805	-0000830	-0597362
01208	89121559	04952	018148548		11601	3915090	0006	1947140	730248	001263	-0421612	-0260422
01228	89171139	18207	767164299		12751	4747152	0215	2499460	702578	036428	-0000457	-0672587
01244	89104416	39962	047177125		11361	3914516	0126	1946580	730268	001585	-0422001	-0259710
01244	89181327	34916	954159433		12431	3913561	0002	1946890	730302	001629	-0421740	-0260064
01245	89131470	94946	039191565		11741	3917979	0008	1947310	730147	001140	-0421602	-0260709
01248	89095548	14207	775244030		11631	4738804	0171	2499940	702843	036054	-0000049	-0672003
01248	89174246	64207	688166449		12791	4740914	0137	2499940	702776	036023	-0000048	-0672125
01249	89121950	24207	562190952		12191	5099388	2087	2499900	691613	027527	-0000086	-0692548
01249	89149097	28207	436163207		12601	5108125	1803	2499900	691347	027279	-0000086	-0693045
01250	89131716	93207	813208265		12161	4731575	0109	2499560	703073	036340	-0000363	-0671618
01251	89020478	35208	468274103		10661	4999772	2033	2499980	694671	034493	-0000018	-0687678
01267	89162570	20217	950427984		11241	3755076	0120	1556550	735811	071277	-0694452	0348408
01268	89117804	73257	181405379		10651	3780850	0106	1557220	734894	070640	-0695550	0347962
01268	89167873	12209	140429289		11341	3781468	0068	1556800	734872	070681	-0695884	0348761
01269	89103469	70263	794401624		10501	3851720	0204	1556820	732385	068205	-0699784	0350678
01269	89147506	71221	106423059		11111	3852577	0124	1556820	732355	068112	-0699811	0350694
01270	89074036	94308	241392180		10011	3825531	1838	1557590	733310	070082	-0698168	0348718
01272	89148880	03936	019143161		11981	3914884	0000	1946990	730256	001394	-0421714	-0260230
01273	89100450	98062	409913708		10751	4762995	0002	2750830	702063	011665	0210417	-0587762
01273	89153290	29078	738874715		11531	4762949	0002	2750850	702065	011423	0210425	-0587736
01273	89169542	58083	871853756		11771	4763027	0002	2750830	702062	011664	0210414	-0587767
01288	89058664	60905	430395674		10171	4863560	1131	2755310	698894	009290	0216048	-0590011
01288	89131281	65077	622901043		11251	4876415	0839	2755010	698492	009068	0216035	-0590886
01290	89101260	09063	122892453		10781	4861927	1455	2750920	698946	011592	0212375	-0592958
01290	89131535	23078	284871654		11231	4869500	1311	2751060	698708	011069	0212625	-0593238
01290	89161116	44081	972838865		11671	4875929	1225	2751130	698507	011747	0212821	-0593572
01291	89085039	32975	334194678		11091	3913130	0009	1946840	730317	001733	-0421757	-0259996
01292	89181310	59916	943133722		12431	3913531	0010	1947040	730303	001478	-0421625	-0260256
01293	89074130	60979	785187194		10941	3915897	0001	1946910	730220	002254	-0421821	-0260154
01293	89151711	71119	344421200	22	12021	3916046	0000	1947260	730215	001286	-0421565	-0260592
01303	89101319	43207	343180546		12101	5666078	0779	2499480	674840	018124	-0000469	-0726146
01303	89134435	14207	303138171		12621	5737812	a010	2499480	672789	015545	-0000476	-0730307
01303	89175611	28207	153094690		13271	5847043	7001	2499470	669696	012783	-0000485	-0736819
01310	89171148	75922	921140979		12291	3915172	0001	1947180	730246	001317	-0421586	-0260475
01312	89102009	95123	715470474		15531	2200483	0001	2675920	797184	091628	0117723	-0501157
01313	89141681	66123	404506154		15811	1962375	0002	2677800	807725	096482	0116144	-0488529
01314	89041645	22595	456026001		6491	2914038	0004	2505070	767555	002545	0003568	-0560490
01315	89104061	98595	873991962		7301	2921168	0003	2506230	767272	002981	0004389	-0560892
01316	89181067	04596	356969895		8291	2914120	0026	2505770	767551	002594	0004063	-0560486
01319	89133193	00207	621177166		12591	5569342	#317	2499620	677631	014364	-0000342	-0719785
01325	89094562	92430	257886206		5561	5439947	3915	1800630	681322	024463	-0606827	-0067809
01325	89178586	08351	192876401		6861	5507161	4621	1800750	679353	022669	-0610035	-0068394
01326	89178231	33347	258871878		6891	5627471	6579	1800940	675863	018991	-0615797	-0069388
01329	89091796	80662	292098467		4581	5138556	0018	2644860	690416	002442	0125933	-0664154
01336	89133707	38276	912400505		10631	3509319	0059	1559320	744709	072504	-0676337	0335313
01339	89049076	88364	772355718		9411	3391021	0038	1559428	074908	7065821	-0669229	0339004
01339	89176770	55250	498413440		11121	3391772	0026	1559486	074905	9065403	-0668785	0337947
01340	89063800	19323	732374773		9771	3650798	0382	1558020	739554	076352	-0688270	0343142
01340	89078453	14309	955382221		9971	3650055	0068	1557530	739581	076403	-0688558	0344015
01342	89108209	13153	13402161		10111	3368915	0057	1557588	307499	140756	70-0668235	0331997
01342	89174032	53256	443431156		10991	3369280	0036	1557970	749900	075812	-0668853	0333540
01343	89163276	87230	835418178		11071	3676013	0256	1557600	738645	070096	-0687936	0343596
01344	89074136	24321	068378287		9811	3581771	0088	1559440	742058	075313	-0682231	0338055
01345	89118308	93320	347407812		8841	3236721	0008	1556230	754897	071204	-0659333	0331248
01346	89088934	86347	842394107		8321	3237350	0018	1559290	754874	075231	-0658863	0326687
01349	89109366	87324	943400770		9161	3275278	0018	1956120	753436	075064	-0661651	0328706
01351	89065158	70371	250390048		8751	3188481	0003	1555940	756737	072689	-0656747	0330357
01351	89177375	33273	917439339		10231	3188930	0008	1555530	756720	072458	-0656946	0331022
01355	89167247	92223	332426133		10531	3724109	0374	1560070	736919	072150	-0690376	0341159
01357	89058222	99655	714144766		4071	5140701	0000	2645180	690351	003130	0126236	-0664162
01357	89078934	81663	373083788		4671	5141893	0000	2644710	690315	002290	0125839	-0664405
01357	89181021	67679	148991029		5931	5146752	0000	2645040	690167	002080	0126183	-0664555
01358	88972615	77455	554182392		2341	3354631	0000	0114355	075033	501913	2-0884206	1076746
01359	89097007	29562	520751432		212	9170926	0000	0089192	096398	004842	1-0605049	0924091
01360	89059570	30659	240585965		90	4647870	0000	0089180	151691	060055	3-0342026	0522425
01361	89140006	60510	450791778		271	9891727	0000	0089194	091654	900133	9-0665915	1017036
01367	89061138	36638	85997383		4001	5292153	0912	2358730	685788	033498	-0125080	-0677774
01367	89088498	73633	454971819		4421	5415378	7989	2358080	682130	030378	-0126897	-0684257
01367	89100800	40631	047959777		4611	5476742		7932357	670680	327028	606-0127889	-0687427
01367	89120767	15627	101941116		4921	5582667		6212357	630677	242025	407-0129001	-0693186

NCAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
01367	89	14	05	81	49	62	30	52	3	15	79	60
01367	89	15	64	37	48	61	97	97	90	22	34	56
01367	89	15	83	31	72	61	94	11	90	23	45	78
01367	89	17	58	87	54	61	56	71	88	38	12	13
01370	89	11	78	52	17	33	77	04	39	13	19	14
01371	89	08	82	85	79	35	27	69	39	27	93	15
01372	89	02	95	19	81	42	49	84	37	09	97	16
01372	89	14	49	45	80	32	92	94	41	92	89	17
01373	89	09	92	54	79	35	19	46	40	64	37	18
01373	89	17	78	32	29	28	46	05	43	95	26	19
01374	89	06	79	80	04	55	37	91	15	34	41	20
01374	89	16	68	31	72	49	21	43	07	77	37	21
01374	89	17	66	85	52	48	58	71	96	42	34	22
01375	89	05	42	08	30	28	91	04	39	78	53	23
01376	89	02	34	09	48	04	35	15	01	60	30	24
01377	89	08	77	28	10	52	38	33	45	54	23	25
01377	89	16	82	82	93	54	64	36	38	86	63	26
01379	89	16	12	67	80	54	45	27	39	86	61	27
01380	89	04	46	10	27	51	18	50	49	92	31	28
01380	89	12	15	35	55	53	36	57	43	43	84	29
01381	89	06	06	55	99	42	60	81	14	10	53	30
01381	89	12	00	37	78	32	51	71	29	59	70	31
01382	89	05	77	15	51	54	03	38	90	96	8	32
01382	89	08	44	81	62	11	12	80	89	36	13	33
01382	89	08	88	58	36	10	48	16	90	34	28	34
01383	89	05	76	17	21	15	14	81	85	48	09	35
01383	89	08	43	54	90	11	11	57	85	70	45	36
01383	89	09	42	76	37	09	62	78	84	91	20	37
01383	89	12	39	23	54	05	21	65	83	41	38	38
01384	89	05	76	41	50	15	18	06	87	70	11	39
01385	89	06	06	56	61	42	62	94	13	61	26	40
01385	89	10	11	68	87	35	73	69	24	95	01	41
01386	89	08	98	44	89	65	39	04	12	39	07	42
01389	89	05	87	04	84	59	54	92	05	20	92	43
01389	89	16	16	95	47	59	59	18	98	92	00	44
01390	89	16	36	76	25	91	81	93	95	95	51	45
01391	89	14	94	82	24	94	71	53	95	48	10	46
01392	89	15	85	37	63	30	62	54	43	06	91	47
85251	89	18	41	64	09	20	74	24	13	82	48	48
85300	89	18	41	39	60	59	60	29	95	92	33	49
85301	89	18	35	48	80	21	78	64	44	52	68	50
85303	89	18	25	89	66	18	39	77	45	41	57	51
85304	89	18	33	33	63	18	53	39	44	61	45	52

NCAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
01367	89	14	05	81	49	62	30	52	3	15	79	60
01367	89	15	64	37	48	61	97	97	90	22	34	56
01367	89	15	83	31	72	61	94	11	90	23	45	78
01367	89	17	58	87	54	61	56	71	88	38	12	13
01370	89	11	78	52	17	33	77	04	39	13	19	14
01371	89	08	82	85	79	35	27	69	39	27	93	15
01372	89	02	95	19	81	42	49	84	37	09	97	16
01372	89	14	49	45	80	32	92	94	41	92	89	17
01373	89	09	92	54	79	35	19	46	40	64	37	18
01373	89	17	78	32	29	28	46	05	43	95	26	19
01374	89	06	79	80	04	55	37	91	15	34	41	20
01374	89	16	68	31	72	49	21	43	07	77	37	21
01374	89	17	66	85	52	48	58	71	96	42	34	22
01375	89	05	42	08	30	28	91	04	39	78	53	23
01376	89	02	34	09	48	04	35	15	01	60	30	24
01377	89	08	77	28	10	52	38	33	45	54	23	25
01377	89	16	82	82	93	54	64	36	38	86	63	26
01379	89	16	12	67	80	54	45	27	39	86	61	27
01380	89	04	46	10	27	51	18	50	49	92	31	28
01380	89	12	15	35	55	53	36	57	43	43	84	29
01381	89	06	06	55	99	42	60	81	14	10	53	30
01381	89	12	00	37	78	32	51	71	29	59	70	31
01382	89	05	77	15	51	54	03	38	90	96	8	32
01382	89	08	44	81	62	11	12	80	89	36	13	33
01382	89	08	88	58	36	10	48	16	90	34	28	34
01383	89	05	76	17	21	15	14	81	85	48	09	35
01383	89	08	43	54	90	11	11	57	85	70	45	36
01383	89	09	42	76	37	09	62	78	84	91	20	37
01383	89	12	39	23	54	05	21	65	83	41	38	38
01384	89	05	76	41	50	15	18	06	87	70	11	39
01385	89	06	06	56	61	42	62	94	13	61	26	40
01385	89	10	11	68	87	35	73	69	24	95	01	41
01386	89	08	98	44	89	65	39	04	12	39	07	42
01389	89	05	87	04	84	59	54	92	05	20	92	43
01389	89	16	16	95	47	59	59	18	98	92	00	44
01390	89	16	36	76	25	91	81	93	95	95	51	45
01391	89	14	94	82	24	94	71	53	95	48	10	46
01392	89	15	85	37	63	30	62	54	43	06	91	47
85251	89	18	41	64	09	20	74	24	13	82	48	48
85300	89	18	41	39	60	59	60	29	95	92	33	49
85301	89	18	35	48	80	21	78	64	44	52	68	50
85303	89	18	25	89	66	18	39	77	45	41	57	51
85304	89	18	33	33	63	18	53	39	44	61	45	52

Related element sets for Pegasus 2 and its rocket From W.P.Overbeck

Improved Elements for Pegasus 2 (65 39A)

1 01381 38918.076929 .221194 .455817 000189 14.819367 10.0

2 .088191 06999.77 0116.66 -1.151032 +1.768327 00 351 14.819367

Elements for Pegasus 2 Rocket (65 39B)

1 01385 38918.083190. .221194 .455817 000189 14.812177 5.00

2 .88191 07002.01 0114.03 -1.151032 +1.768327 00 351 14.812230

(Note similarities that exist for same revolution number)

Current Gear Ratio Elements Derived by NASA GSFC from NORAD Data as of 38939.9

ICAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
00004891999542957934239575 3					30771	38249010073092187073315506138					3-1042834	1558789
00004893214611940388465674 4					33245	13827727010209218907330550611					5-1042982	1558983
00005892010023225395849562 9					28366	10747091000009513408672381652					61-0781591	1142404
00005892503165021248755531 7					28419	10747218001009514308672311644					11-0780969	1141411
00011891937957201359494249 3					26419	11480948000509131408298581361					91-0850653	1279692
00011892957034891401509206 8					26536	11480976000209133408298561363					19-0850672	1279534
00012891882898843081479095 6					24968	11106083000109140208484331548					32-0824278	1239218
00016892141822256826656947 4					22632	10403747000009516908862201833					90-0758570	1108449
00020892112852856270253692 6					23176	11091410000209260308491841602					30-0822688	1225928
00020892987396848279065565 5					23273	11091484000409259808491801600					40-0822570	1225795
00023893221314213821863434 9					29620	14271473000813980307179090251					91-0820043	0666447
00028892270228170085382736 3					27556	14529654000213440807093630026					64-0871638	0790874
00029892699016368188282762 7					27601	14517397000113439807097620025					72-0870717	0790187
00031892986360152934578153 1					28827	15370505016714233906832710111					74-0886081	0679092
00043892248154874330665740 8					28130	15273016000009177306860260008					91-1176397	1763804
00045892352940238104981705 0					25737	14171870000418530107213850220					42-0502750	-0138754
00049892009262472097924523 6					21941	12683586014613138807766250469					54-0748033	0716702
00049892174817970497025997 5					21963	12684445020113121407765890470					56-0749014	0719803
00049892395609368418228810 3					21991	12685600020113136907765420476					21-0748451	0717348
00050891962639654094734149 5					21738	12197105000013119807971430091					64-0705941	0678601
00051892263381256357733588 2					21487	12178518000013130107979540082					40-0703974	0675501
00058892199512824845013582 6					23008	13453709000107860307465540127					33-1043976	1705231
00060892257326922844903446 3					21532	12825846000813870707708900912					64-0735805	0612450
00060893309869512929311683 9					21667	12826222001713864307708740911					96-0736156	0613580
00062892415814612478712098 5					21611	12880342002513865007687130890					15-0739382	0616173
00063892227795592892492104 2					24342	14659427000313465607051710052					03-0880559	0795240
00063893114591981469202355 1					24472	14659460002134700705170005104					-0880279	0794314
00064892054579989507294156 8					24344	14680082000913467407045090053					43-0882104	0796356
00064892715780280990208469 7					24441	14680158000613481807045070067					72-0881266	0793425
00082892527154854873978707 0					19177	12149950000110792507991420978					32-0830044	1083079
00099892494160297945364106 1					28054	14888654000414232106979350125					70-0849451	0651297
00162892518012016117336488 1					20548	14342365000213304207155220035					29-0864958	0804839
00188892434678978736308200 6					12766	89309560000253239098141700998					7 0013958	-0342199
00192892386051760059421453 7					11542	86768870000266634100047501324					1 0068857	-0312058
00205892668152141777113434 5					17797	13610193000009004407408450075					36-1016013	1542469
00227892539713585273764806 0					17360	14207809000013370207200350120					34-0850660	0782060
00255891989337302296782160 8					17828	14995175003309120906944770013					64-1150579	1732203
00255892749292089177497465 4					17942	14995098000609119906944790012					60-1150622	1732403
00257892091868701694485068 5					17838	15003050000809120806943180017					43-1151117	1733031
00257892956736865753152950					17970	15005380011091207069431100172					8-1151147	1733091
00271891858052388201986547 2					10871	94128640000240676094763503110					1-0043153	-0362196
00271892166117988076585265 4					10900	94128630000240562094763503156					2-0043681	-0362063
00271892431735887969284596 3					10925	94128470000240678094763603118					1-0043144	-0362200
00271892888559587783483069 5					10968	94129070000240589094763203136					0-0043557	-0362091
00285892070173628575006609 6					16310	14337266002614964507157390390					18-0764633	0478591
00285893214054816018709131 0					16474	14338135004214958107157100384					59-0764985	0479792
00288892129732626005002848 4					16328	14356573007614955807150970375					92-0766261	0480946
00288892526843021603706881 4					16385	14356753004714955407150910383					14-0766464	0481134
00288893341745312627212150 1					16502	14357591005114962907150630377					27-0765899	0479639
00309891901680338518297764 3					15543	14332891000016140907159160190					46-0681751	0255279
00311893153288424310402728 8					15735	14346744000416142307154558818					-0682508	0255338
00340892613696503571311685 5					9772	91262040002124434096719523496					1-0565797	0605086
00341892108044205094510130 3					9736	91357800001124412096651923433					1-0566384	0605905
00370892774543555686248711 0					15071	14660745000527393507053240069					39 0198936	-0589393
00378892726574339522308582 9					14682	14288531000227426407175150178					30 0195059	-0568147
00388891217024443300793237 2					14653	14471803000027415807114470119					29 0197410	-0578141
00388893041298648522478643 6					14917	14471903000227415807114430117					43 0197407	-0578137
00397892014701904024678235 1					14508	14585389000116204007076320012					17-0692378	0249216
00444892516505083174176690 7					10111	14023711302198351083391917610					8-0331738	-0255770
00444892981040781385675414 5					10164	14183842007198323083313917453					5-0332042	-0255589
00502892215698996740015990 3					11791	13534610097619536607438700826					71-0411822	-0265264
00502892540701394934314844 9					11835	13541597101619537507436140825					19-0412010	-0265537
00502892983586092449113221 3					11895	13554073151619540307431580819					24-0412174	-0266121
00503892036458637830129864 3					7069	77810500027132398107570729888					6-0451395	0424903
00503892691922435570532485 3					7120	77809870000131958107571130576					1-0456301	0432874
00504892209663116085828462 5					11551	12961570030819551407656321041					39-0392607	-0255267
00504892749634713315226644 8					11621	12965426034519545907654801040					54-0393124	-0254720
00504893004125212032225813 2					11654	12968593049219548007653551031					71-0392859	-0254893

EXHIBIT F

Current Gear Ratio Elements Derived by NASA GSFC from NORAD Data as of 86999.5

NCAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
00509	89253	89779	66080	60347	82	13201	14536	31000	03251	83907	09352	00204	242	0015167	-0655832
00515	89193	00154	37632	63046	40	7069	77902	04000	01320	04107	48633	03037	93	-0455975	0432209
00515	89244	34832	35747	73231	18	-79	77899	01000	01327	43107	48923	05554	2	-0454541	0425240
00515	89273	87227	34729	33321	90	7132	77901	96000	01321	19107	48643	03903		-0455672	0431047
00515	89294	41127	34036	53401	01	7148	77902	92004	61317	95107	48543	06437		-0458027	0435748
00527	89211	76299	79776	64361	11	13337	15252	80015	22749	80686	96900	3001		-0197211	-0630274
00533	89221	49134	28341	87574	32	12416	14744	08200	09279	08807	02660	01479	1	0243327	-0558853
00534	89215	17427	28154	37637	23	12407	14741	97990	04279	09607	02726	01457	6	0243345	-0558669
00536	89250	51163	24739	78081	08	12376	14647	70600	10279	06007	05737	01560	0	0241006	-0554244
00564	89233	91808	32252	44533	95	12120	15321	82301	79160	10306	84768	02146	8	-0755405	0305274
00564	89312	88469	23385	95746	97	12241	15325	48502	55160	13606	84659	02143	3	-0755390	0304699
00573	89262	79040	25812	38299	12	4920	63914	01000	01187	71122	64414	92105		-0457976	0528774
00574	89229	74364	43784	08252	93	6611	86524	98000	02426	46100	23570	01907		-0030360	-0325163
00575	89182	97727	27825	38063	61	4874	63979	93000	01187	67122	55984	91976		-0458768	0529723
00594	89231	45389	97855	50438	05	10501	14456	66000	42500	29071	23150	01707		0000234	-0650819
00602	89286	39282	43645	91015	46	6675	86710	80000	32427	61100	09250	01635		-0029968	-0326202
00604	89219	33393	33146	24664	18	10679	14781	00000	01161	79107	01375	00061	9	-0706575	0258391
00605	89213	84141	32394	13832	81	10678	14794	65500	05161	78007	00943	00055	8	-0707520	0258909
00608	89215	12394	43872	32509	57	6599	86528	16004	32425	61100	23320	03201		-0030712	-0325099
00608	89249	81070	43800	62539	60	6629	86525	96001	22426	71100	23490	02787		-0030257	-0325191
00612	89201	72085	81654	30573	94	10034	14114	78400	14138	10507	23208	04402	7	-0822490	0693394
00612	89320	03449	67926	81727	70	10201	14115	21000	18138	11307	23194	04392	4	-0822448	0693243
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00614	89251	75215	91148	43450	52	7763	10894	61600	27228	19808	59661	18777	3	-0134566	-0446787
00614	89333	44194	89949	73050	87	7852	10895	17400	39228	19108	59632	18792	3	-0134646	-0446859
00622	89275	45131	04542	79265	60	5994	85791	96000	02459	24100	80580	02978		-0016642	-0323897
00622	89310	36575	04452	78704	13	6024	85791	80000	02456	85100	80590	02803		-0017616	-0323768
00624	89198	33975	03885	59021	59	5924	85909	42000	02448	26100	71400	82055		-0021443	-0328175
00624	89244	90329	03799	89181	9	5964	85910	62001	12449	13100	71300	81995		-0021084	-0328231
00624	89308	92583	03679	78756	76	6019	85910	87000	82449	06100	71290	81851		-0021110	-0328211
00630	89105	98217	04741	39550	70	5858	85974	02000	12456	53100	66340	03246		-0017796	-0324668
00630	89235	10257	04543	89291	18	5969	85974	31000	22455	90100	66320	03297		-0018054	-0324635
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00705	89304	87887	27706	41024	14	7550	13445	13500	00249	88007	47214	00330	0	-0000888	-0591459
00714	89293	21966	74621	62106	64	6811	12494	83901	07218	51007	84607	08477	2	-0215891	-0443060
00717	89195	03330	06517	29806	96	7760	14503	47800	02162	52907	10295	00239	0	-0683778	0238377
00729	89197	91615	30501	01809	61	7154	13921	29700	00019	41960	73003	00011	83	-0425658	-0254089
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00735	89250	77296	39788	06521	77	7272	14215	03600	04275	29307	19984	00107	8	0201621	-0557256
00737	89187	81739	07695	78056	59	3719	73953	62000	01282	68111	27852	72971		-0418111	0421874
00737	89236	49680	06232	38213	20	3755	73954	11000	01283	88111	27612	71891		-0417364	0420324
00737	89309	51729	04066	18464	45	3809	73954	07000	31286	73111	27822	66501		-0414517	0415554
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00738	89246	48364	06116	98265	09	3761	73924	76000	01286	49111	30762	64230		-0413479	0414670
00740	89212	84781	96907	35453	32	6653	13295	77800	65226	42207	52788	01429	4	-0172145	-0519609
00740	89291	05149	95112	34755	30	6756	13297	22100	90226	40207	52733	01369	6	-0172304	-0519548
00744	89251	63976	18190	04942	23	7697	15526	40203	17087	34606	78467	01547	8	-1225317	1895322
00744	89293	49537	10197	16178	48	7762	15531	83905	32087	35206	78367	01558	3	-1225665	1895774
00746	89187	87771	51857	54229	01	4204	85072	68000	11692	64101	36603	35671		-0393901	0072973
00746	89311	30070	14439	32375	64	4309	85073	09000	01692	64101	36573	35668		-0393903	0072976
00759	89291	01354	36712	66263	68	7243	15226	30900	15227	98606	87757	00097	9	-0192510	-0631764
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00771	89258	83162	53111	29353	42	6348	14386	53902	00143	59107	14087	04774	9	-0810074	0601943
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00775	89297	96004	45099	19942	03	6424	14473	68907	31143	36507	11216	04420	0	-0817093	0610621
00775	89327	66426	41590	70129	44	6467	14474	67902	67143	45107	11118	40430	3	-0816277	0608710
00784	89220	36784	93742	58149	18	6641	15707	52402	11161	36406	73516	00074	83	-0769742	0289029
00784	89311	39584	82743	36582	66	6784	15712	11902	81161	33706	73385	00067	98	-0770217	0289675
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00812	89217	65537	18896	46674	47	5069	14178	64801	41277	11307	21213	00015	9	0215255	-0543620
00812	89239	54217	19546	66784	41	5100	14177	55900	02277	11107	21250	00008	03	0215222	-0543574
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Current Gear Ratio Elements Derived by NASA GSFC from NORAD Data as of 38939.9

NCAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
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00851893310500733155007715	2				35251	13656590	14626584	50835752	1	70883	0102359	-0489483
00864892547003225769753732	5				44201	52501080	82313603	20686844	0	26896	-0921800	0810620
00864892986228019590859380	3				44871	52611081	48513598	70686513	0	26948	-0923005	0812408
00864893228631616182162176	5				45241	52649030	83113600	10686399	0	26696	-0923165	0812322
00866892118616022417357120	6				44001	56271001	84713580	70675750	0	17214	-0952176	0841047
00866892157005421855857551	5				44061	56285751	87813589	90675708	0	17216	-0951664	0839084
00866892412821918040560870	8				44461	56421322	45013591	50675317	0	16563	-0952562	0839687
00866892483020217011260154	6				44571	56467012	69513580	70675186	0	17491	-0953811	0842495
00866892987497209456067896	7				45361	56867175	37413591	90674037	0	15510	-0956017	0842579
00866893146723007075068412	4				45611	56976914	57913585	70673723	0	14054	-0957163	0844632
00867892266616629158550739	5				43801	52532530	77013594	50686749	0	26621	-0922580	0812706
00867893072634417804460923	5				45031	52700911	30413600	10686244	0	26188	-0923479	0812596
00867893341106114027464175	3				45441	52736140	81513594	60686138	0	26164	-0924126	0814050
00870892133937982320849445	2				40021	38571890	00022197	80732319	0	07394	-0215748	-0521392
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00913892210162261924213968	6				36281	59502651	29013602	60666591	0	05009	-0975823	0858240
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00913892943272950485423779	4				37451	59710792	10213590	30666011	0	04782	-0978374	0862555
00913893012143749405248082					37561	59741822	16013591	70665925	0	04819	-0978533	0862464
00924892247451147502999078	7				31491	45146500	00031443	30070988	0	02612	-0809798	0590487
00925892405016675042534357	4				33531	51840070	04022789	60689033	0	00753	-0192576	-0628887
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00947893072953516747563283	6				30011	57640900	92813533	70671828	0	09609	-0965725	0860857
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00979891686179513124746247	2				16251	20721550	00026787	10802822	0	93423	0117991	-0493451
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00987891988694635766629550	3				18701	49278410	00109123	50696565	0	04347	-1143653	1715889
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01090892480383886954557357	0				15421	37419170	13815565	30736281	0	71764	-0693743	0348079
01090893229839879809160967	5				16451	37447540	14715566	00736180	0	71665	-0693856	0348037
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01097893230998876295637195	6				17131	48796520	00418064	30698318	0	03993	-0571727	-0073857
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01208892135765589801815819	7				12881	39150300	00019470	40730251	0	01801	-0421690	-0260292

Current Gear Ratio Elements Derived by NASA GSFC from NORAD Data as of 38939.9

NCAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
01228892036880420784313247	6				1323147479660216249946070255203652						-0000457	-0672655
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01325892230145330900087369	8				755155556245824180052067794102162						4-0612647	-0068269
01325892935271124103986152	5				865156473197462180029067529101936						3-0617416	-0068369
01326892038001332251086895	4				729156608246795180091067490301791						4-0617471	-0069518
01326892242116530272686663	8				761156932597982180058067397301750						3-0619407	-0069136
01326892439462428347386229	4				792157224857873180098067313701662						0-0620540	-0069988
01326892775999925043086515	2				845157818030420180039067145001413						5-0623942	-0069281
01326892833051124519487743	2				854158013339754180031067089601361						6-0624996	-0069257
01326893072961722108686456	6				892158677327 764180094066902701358						3-0627977	-0070758
01329892034349968353599127	3				627151387670011264487069041000250						1 0125949	-0664161
01329893045070870278290227	4				780151391210017264493069039900242						7 0125999	-0664158
01335891883031131309844398	8				952128370000000115599407704880740						71-0631163	0312068
01336892173507220039143871	2				1176135103540072155893074467107209						3-0676512	0335972
01336892958057312865747533	1				1282135119000011015592907446140720						62-0676372	0335366
01337891986833620600643846	1				1151136464930333155946073971007031						6-0684805	0339299

Current Gear Ratio Elements Derived by NASA GSFC from NORAD Data as of 38939.9

NCAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
01338891343821427221239	1467	10421	3584249019915624707419690712	57	-0678980	0332026						
01338892469913616791244	1251	11951	3589587025615629407417750710	82	-0678981	0331342						
01338892801032413732745	7234	12401	3591784034415625807416940707	06	-0679231	0331997						
01340892059093818996044	2780	11711	3653234011015591807394670758	22	-0687490	0341058						
01340893121012509012149	2445	13161	3655930013115596607393690758	90	-0687385	0340285						
01341892233849319289845	0558	11831	3496310005415560607451860739	57	-0678039	0340887						
01341893071085011621848	9237	12961	3497452007715557607451440736	95	-0678208	0341399						
01342892024548923101544	2806	11371	3696100110155798074988707586	4	-0668886	0333540						
01342892219017121355245	1059	11631	3705940605155841074985107626	5	-0668828	0332892						
01342892376096219958245	8715	11841	3696680033155795074988507581	8	-0668889	0333580						
01343892034911319304443	6617	11621	3677653025915578407385860702	49	-0687949	0343250						
01343892437008215522545	5356	12171	3679143020915574807385320699	97	-0688196	0343911						
01344892368456217012545	3654	12021	3583333004915596107420010753	22	-0682233	0337811						
01345892036774224588344	5254	9971	3236885001715566307548910711	96	-0659092	0330555						
01345892535403420215146	9154	10631	3236958003915562607548880711	76	-0659321	0331200						
01346892672140919235347	1071	10681	3237895001415596807548540752	46	-0658668	0326046						
01347892530403322167244	5324	9901	3143826000415575907584500610	41	-0649164	0324241						
01348891978138926445944	1392	10441	3152143000515601607581310749	28	-0652468	0322307						
01348892981775017829348	4251	11761	3152281000715600307581260746	23	-0652451	0322472						
01349892276309922087445	2297	10731	3275486001115584107534280747	36	-0661821	0329410						
01351892425805221714946	8299	11091	3189402003515555007567020727	45	-0657097	0331149						
01351893130927815611150	0044	12021	3189695004715552707566900726	92	-0657236	0331534						
01352891241725727054140	1801	9071	3645967032015596207397290733	47	-0685768	0339542						
01352891967088820251143	4891	10061	3650545031715596607395640734	93	-0686110	0339656						
01354891331490129066841	4332	10661	3382980007315560907493870719	81	-0669596	0336602						
01354892422366019291146	3425	12121	3844800067155658074933207207	5	-0669427	0335824						
01355892306271216290545	5293	11401	3729293039715594307367330722	38	-0691178	0342505						
01356891280354122215427	7716	10991	4383855582915622507142110537	10	-0727688	0356197						
01356891980526314799646	1441	12001	4470312648215617107113630515	17	-0733288	0359782						
01356892359836310744161	8618	12551	4527233699815615307095040491	75	-0736614	0361711						
01356892717253206924750	1526	13071	4571727626015621907080580480	91	-0738875	0361758						
01357891929494068147204	8363	6111	5	1481610000	2645370690124002	225	0126485	-0664508
01357892239902268731904	2544	6581	5	1499150000	2644520690071002	250	0125763	-0664948
01357892338555668898497	9936	6731	5	1511910000	2645420690032001	983	0126561	-0664663
01357892575771869374089	8929	7091	5	1521630000	2645270690000300	291	0126439	-0664782
01357892741753769689803	5213	7341	5	1534760000	2645240689963001	668	0126434	-0664863
01357892906597170007300	1994	7591	5	1558140000	2645250689892001	532	0126464	-0664997
01357893005312170176195	5506	7741	5	1578490000	2645040689830001	667	0126302	-0665201
01358892242132415837154	3437	5711	3	5463000000	1143760750335019	047	-0884096	1076359
01358892541670312296258	8735	6111	3	5476400381	1434407503300189	46	-0884251	1076946
01358893125723005383357	0576	6891	3	5466400121	1435107503340193	94	-0884262	1076868
01359892529348747588588	3805	355	9	1709230000	0891300963980048	205	-0605170	0924679
01361893099797939807009	6146	439	9	8917180000	0891790916550001	103	-0665949	1017197
01370891178521733770439	1319	10031	3	1276440000	1557000759073061	667	-0648622	0324800
01370892869618619386646	4229	12251	3	1276710006	1558720759073062	259	-0647745	0321972
01371891976574325844544	0285	10971	3	1660550000	1552530757595064	603	-0654754	0334112
01371892971551917257548	3391	12281	3	1659850000	1551600757598064	295	-0655221	0335643
01372891449445732906141	8249	10361	2	9955870009	1559040764207068	91	-0640441	0317902
01372892719144022260647	4526	12011	2	9954390004	1555070764212067	731	-0642704	0324485
01373892312370123886146	5728	11581	3	1082710004	1557880759821074	631	-0650799	0324663
01373893121026916971750	1535	12641	3	1084950018	1558480759813074	842	-0650521	0323687
01374892138701546246403	5587	3641	6	1923648990	2084270660111003	112	-0391431	-0505135
01374892212748945775102	9666	3761	6	2118888506	2084000659581002	746	-0392306	-0505620
01374892409899244512940	2496	4081	6	3263245	4272083530658192	002	88	-0394396 -0507184
01374892569371843485299	7380	4341	6	3309420	9279208319065637	300	130	1 -0396896 -0509581
01375892156574312298545	3904	12321	4	8626262	9415461906987860	631	93	-0775532 0406160
01375892728100506040251	0464	13071	4	3587021530	1555690715043057	484	-0731652	0368425
01376892056083210129186	6852	12381	4	9296940020	2749480696830006	065	0212363	-0597279
01376892933451112914577	7380	13691	4	9298060005	2750006696826006	125	0212851	-0596908
01376893174584013647675	6993	14051	4	9302760065	2748890696812006	588	0211879	-0597717
01377892175886956019734	8304	3041	4	4001470006	2739660713804020	344	0194760	-0576112
01377892335598456476933	3909	3271	4	4001520002	2739990713804020	391	0195032	-0575914
01377893092533958602727	1134	4361	4	4001850002	2739990713803020	390	0195032	-0575916
01378892377600956584933	1915	3331	4	3981120002	2739560713871020	523	0194653	-0576076
01379892931470658131328	8644	4131	4	4071310004	2739980713574019	803	0195134	-0576236
01380893037146958541328	3195	4291	4	4460907102	7423707123390196	89	0197743	-0576770
01381892064125417814352	3876	2281	4	8193680000	0881960699953011	128	-1146854	1763716
01385891808311822190345	4107	1901	4	8120820000	0881790700183011	436	-1146209	1762932

Current Gear Ratio Elements Derived by NASA GSFC from NORAD Data as of

NCAT	JNE	AJNE	AQNR	ANRP	IPRM	APRM1	M2	ANGR	CP	CG	GR1	GR2
01385893145059299495380316	8		387	14812071000008817907001	8	3011436		-1146208	1762931			
01389892337172859628295245	3		897	12914831000025051907675	2	3002499		0003652	-0560535			
01389893181155959676088944	6		1006	12914557000025054407675	3	4002602		0003830	-0560517			
01392892236159525119845813	0		1187	13061156000915543107616	4	6068686		-0647856	0328127			
01394891937963012992181017	0		016	248483	1761798780658	5330041	61	-0649529	-0069001			
01394892166044710603286121	2		371	6295563	8491797980657	2640012	25	-0652691	-0067770			
01396892110617282698316337	6		316	0264783712208526066465	7009	227		-0385324	-0499582			
01396892210415182079915751	9		1916	0376683434208521066434	8008	927		-0385718	-0499979			
01396892434807980692713841	1		551	6048732270220853406640	4200	8712		-0385956	-0500570			
01396892882742977911109050	2		1271	6135943	3822085260661	6490062	13	-0388754	-0504031			
01396893000330777186808760	7		1461	6189796Z283208488066018	1005	554		-0390824	-0505802			
01396893197348375915806209	5		1781	6292743L52120850906573	9700	3303		-0393907	-0510298			
01396893325394775091898991	0		1991	6437876C042208493065352	6001	155		-0398723	-0516152			
01397891370489528677440837	0		1063	1340471800481558510748	5780	71818		-0669501	0333087			
01397892273143220563544859	7		1184	1340464700001559130748	5800	71147		-0668874	0331881			
01397892661046617077246496	3		1236	1340539500581559680748	5530	71277		-0668623	0330967			
01398891376844031331041195	1		1045	1321317500171566250755	7970	79832		-0654586	0314757			
01398892572621720942846352	5		1203	1321366200141566500755	7780	79548		-0654360	0314295			
01398893162886115865148737	7		1281	1321494000971567230755	7300	79304		-0653908	0313058			
01399891764265659629198563	3		823	1291399600002505320767	5560	01762		0003747	-0560479			
01400892909426906299150699	0		1330	1415701347421556770721	8180	56113		-0716653	0359213			
01401892005532418404644741	1		1175	1386484307531562110731	9240	70291		-0697980	0341859			
01401892921046709509849099	9		1302	1387917507971562220731	4200	70147		-0698836	0342121			
01401893029100208456949790	3		1317	1388359411761562210731	2650	69818		-0699024	0342230			
01401893302764905849650738	0		1355	1388546004421562620731	2000	69384		-0698720	0341454			
01402892557570814274646568	5		1241	1369110501281559030738	1020	71652		-0688612	0341831			
01402892725670412617747323	3		1264	1368042800001559450738	4860	73729		-0688377	0341091			
01402893222562007886949759	9		1332	1368634502941557520738	2730	73651		-0690002	0344753			
01403892608888010285548379	8		1290	1408427811231557140724	3010	59999		-0712677	0356664			
01403892928291307083250169	1		1335	1409675523041556640723	8730	58726		-0713450	0357814			
01403893126889405096851065	3		1363	1410061911471556750723	7410	58743		-0713646	0357740			
01404892646785323618485053	9		016	0138364145180648066495	1006	023		-0630560	-0081566			
01404892677819323311483196	3		516	0478993024180604066401	0005	372		-0632708	-0080993			
01404892852217521538582009	3		3316	0525191528180601066388	2005	923		-0632993	-0080975			
01404893313048616852781267	4		1071	6062001093018060306636	2100	5657		-0633468	-0081067			
01405892678093023302086328	1		516	0116773024180611066501	1005	832		-0630756	-0080885			
01405893108709918943091543	5		741	6058046453218061206637	3000	4236		-0633142	-0081201			
01405893307848116913090582	4		1061	6074178435418061406632	8600	3997		-0633960	-0081360			
01406892783782422186487132	5		2216	1662110465180635066076	7002	601		-0638598	-0082354			
01407892745956722627880638	3		1616	1634019Q740180591066084	3004	771		-0638878	-0081540			
01408892726998322823079866	0		1316	2014429M625180519065980	8002	163		-0641450	-0080478			
01409892662350314024348374	3		1244	1367290309241556890738	7570	68965		-0687783	0344574			
01409892859793312166349246	8		1271	1367638609091556850738	6310	68843		-0688002	0344736			
01409892925566811542249641	6		1280	1368263519191556760738	4060	68894		-0688504	0345117			
01410892710852112821247561	6		1251	1369418802111558870737	9910	71266		-0688783	0342148			
01410893032102409743349037	6		1295	1369523100001558130737	9540	70882		-0689193	0343446			
01410893112400209022649327	4		1306	1369815502951557930737	8490	70901		-0689529	0343912			
01411892102915766250201375	3		2478	1237434900032260050789	6980	97583		-0164031	-0484469			
01411893193883864043494894	9		2613	1237438600002260130789	6960	97691		-0163987	-0484547			
01412893047852274917967589	2		151	6340849004408928306557	8000	1131		-1300357	1984777			
01412893157958872576670993	6		321	6350217366308928306555	3000	1049		-1301350	1986293			
01413893151271572719761840	4		321	6377063V877089258065481	3000	672		-1304324	1991172			
01414892864403678042819564	8		1241	6328634G661208705065651	1007	590		-0393324	-0514251			
01416892863952012990848047	1		1270	1358618002141561480741	8980	74453		-0680906	0334418			
01417892716757107128850289	0		1327	1433361411851556940715	8770	50769		-0726999	0364136			
01418892709194302832752631	8		1367	1476678433341555980701	8080	46190		-0756053	0380235			
01419892705382005118551564	5		1345	1454630927051555700708	8810	49096		-0741929	0373582			

Elements for Pegasus 1 (65009A) — From W. P. Overbeck

1 001085 38930.095765 .371791 .346053 001818 14.844149 4.12
2 .088180 06992.00 0113.87 -1.151032 +1.768327 00 351 14.844120

Elements for rocket (65009B)

1 001088 38930.101672 .373969 .343738 001817 14.834818 4.00
2 .088190 06994.68 0114.04 -1.151032 +1.768327 00 351 14.834738

Note: the satellite has gained more than a full revolution on the rocket and, as of June 19, 1965, the rocket follows by about 10 minutes. The orbits of these two are so similar to the Pegasus 2 objects that the same tracking tables and same gear ratios can be used for all four objects.

EXHIBIT G

Phone: STerling 3-4100

INDEPENDENT TRACKING COORDINATION PROGRAM

824 Connecticut Avenue
Washington 6, D. C.

BULLETIN

May 26, 1965

1. SUPPRESSION OF "SPACE JUNK" DATA IN AIRMAIL ANNOUNCEMENTS
2. INDEX OF IDENT DESIGNATIONS CORRESPONDING TO CATALOG NUMBERS 1208-1383

Clear Channel Announcement Service

Well over half the orbital data generated by space surveillance activity relates to debris. Some sort of filter is needed to keep "space junk" data from displacing potentially useful information from the Independent Tracking Coordination Program's Airmail Announcement Services, as described in ITCP Bulletin of May 4, 1965. The filter consists in a SPACE JUNK LIST and a computer subroutine that "weeds out" unwanted data in preparing copy for Airmail Announcements.

Space Junk List

The "Space Junk" List currently in use (see below) was compiled from Smithsonian Astrophysical Observatory data identifying certain objects as "debris". A few objects which have been recognized as long-lived bright objects of some interest have been eliminated from the list. The current "Space Junk" list contains over two hundred 1961 OMICRON fragments. Half of the remainder are de-spin weights from TIROS satellites. The balance may contain objects of interest which will be deleted from the list, and thus reinstated, upon request to this office. Such requests should indicate the observer's basis for his belief that he will be able to secure observations.

New "debris" of significance only to surveillance activity is constantly accumulating. The listing now in use considers only objects through NCAT-1330. The catalog numbers of additions to the SPACE JUNK LIST will appear from time to time in the Announcement Service.

Machine Weeding

Use of the SPACE JUNK LIST does not destroy information. The computer subroutine is designed to compare the NCAT of each set of current gear ratio elements about to be printed with the items in the list. If the NCAT also appears in the list, the printer merely skips to the next set without making an entry. The machine record containing the suppressed information is unaffected. It remains in the file in the same location as before, and is as accessible for retrieval as though it had not been suppressed in the printout.

The program is currently set to eliminate data on space junk items thru NCAT 000.

Current SPACE JUNK List by NCAT Number

00036	00138	00194	00254	00332	00412	00480	00557	00658	00742	00936
00069	00139	00195	00260	00333	00413	00508	00558	00659	00743	00937
00074	00141		00261	00334	00414	00510	00559	00660	00745	00939
00075	00142	00210	00262	00335	00415	00511	00560	00661	00749	00940
00085	00144	00211	00263	00336	00416	00513	00561	00662	00750	00941
	00145	00212	00264	00337	00417	00514	00582	00672	00751	00967
00101	00146	00216	00265	00350	00418	00516		00684	00753	00975
00105	00147	00220	00268	00351	00419	00520	00606	00685	00760	00976
00115	00148	00223	00275	00352	00420	00523	00607	00686	00761	00977
00118	00149	00224	00299	00353	00421	00530	00610	00692		
00119	00150	00225		00354	00461	00531	00611	00696	00805	01092
00120	00151	00228	00300	00355	00462	00535	00628	00697	00806	01094
00121	00152	00229	00301	00356	00463	00537	00629	00698	00809	01099
00122	00153	00230	00312	00357	00464	00538	00631	00699	00815	
00123	00154	00232	00313	00358	00465	00539	00643		00831	01250
00124	00155	00233	00317	00359	00466	00540	00644	00700	00832	01251
00125	00156	00234	00318	00399	00467	00541	00645	00701	00840	01289
00126	00157	00235	00319		00468	00542	00646	00702	00841	01290
00127	00158	00236	00320	00400	00469	00543	00647	00706	00847	
00128	00159	00237	00321	00401	00470	00544	00648	00715	00873	01303
00129	00161	00238	00322	00402	00471	00545	00649	00720	00874	01312
00130	00166	00239	00323	00403	00472	00546	00650	00722	00875	01313
00131	00167	00243	00324	00404	00473	00547	00651	00723	00898	01316
00132	00172	00244	00326	00405	00474	00548	00652	00724	00901	01319
00133	00175	00245	00327	00406	00475	00549	00653	00725	00903	01[redacted]
00134	00176	00246	00328	00407	00476	00550	00654	00726	00926	
00135	00177	00250	00329	00408	00477	00551	00655	00732	00927	
00136	00178	00252	00330	00709	00478	00552	00656	00736	00934	
00137	00179	00253	00331	00410	00479	00556	00657	00739	00935	
				00411						

INDEX OF IDENT DESIGNATIONS CORRESPONDING TO CATALOG NUMBERS 1208-1383

NCAT	IDENT	Popular Name	NCAT	IDENT	Popular Name	NCAT	IDENT
1208	1965 16E	EGRS II	1314	1965 27A		1347	1965 20S
1228	1965 17C		1315	1965 27C	EGRS IV	1348	1965 20T
1244	1965 16B	Grav. Grad. II	1316	1965 27C		1349	1965 20U
1245	1965 16J	Rocket Body	1317	1965 28A	Early Bird	1350	1965 20V
1248	1965 17D		1318	1965 28B	Rocket Body	1351	1965 20W
1249	1965 17F		1319	1965 17G		1352	1965 20X
1250	1965 17B	EGRS III	1323	1965 17H		1353	1965 20Y
1251	1965 17E		1324	1965 30A	Malnia I	1354	1965 20Z
1267	1965 20A	Cosmos 61	1325	1965 30B		1355	1965 20AA
1268	1965 20B	Cosmos 62	1326	1965 30C	Rocket	1356	1965 20AB
1269	1965 20C	Cosmos 63	1328	1965 32A	Explorer 27	1357	1965 31G
1270	1965 20D		1329	1965 31B		1358	1965 32B
1271	1965 16A	Greb	1330	1965 33A		1359	1965 34A
1272	1965 16H	Dodecahedron	1335	1965 20E		1360	1965 34B
1273	1965 21A		1336	1965 20F		1361	1965 34C
1288	1965 21B		1337	1965 20G		1363	1965 35B
1289	1965 21C		1338	1965 20H		1367	1965 33B
1290	1965 21D		1339	1965 20J		1374	1965 37A
1291	1965 16D	Solar Rad.	1340	1965 20K		1377	1965 38A
1292	1965 16C	Grav. Grad. III	1341	1965 20L		1381	1965 39A
1293	1965 16F	Oscar III	1342	1965 20M		1382	1965 40A
1298	1965 23B		1344	1965 20N		1383	1965 40B
1303	1965 17A		1345	1965 20Q			
1310	1965 16G	Surcal	1346	1965 20R			

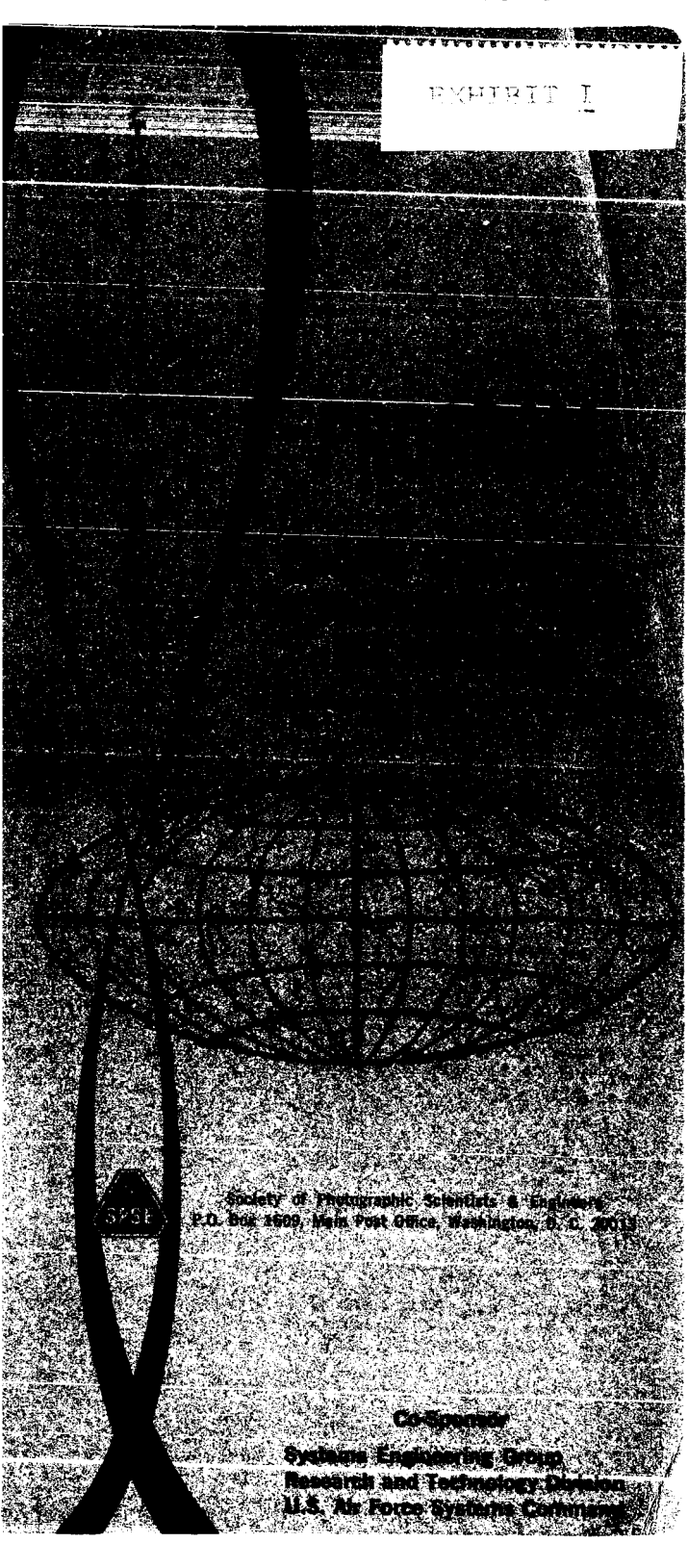
EXHIBIT H

LIST OF SATELLITES BELIEVED TO BE TRANSMITTING AS OF JNL = 38883.

(Channels operating on COMMAND only are listed with letter C in place of the decimal point.)

IDENT	NAME	NCAT	MC/S
61 15A	Transit 4A	00740	54C 324C 150C 400C
62 15A	Airel 1	00285	136.406
62 49A	Alouette	00424	136C59 136C077
62 60A	Anna 1B	00446	162C0 324C0
62 68A	Relay 1	00503	136C140 136C620
63 13A	Telstar 2	00573	136.050
63 22A		00594	150C0 400C0
63 24A	Tiros 7	00604	136.233 136.924
63 38C		00671	136.653
63 46A	Expl. 18	00693	136.111
63 49B		00704	150.0 400.0
63 49C		00705	54C 162.0 324.0
63 54A	Tiros 8	00716	136.233 136.924
64 01C	EGRS I	00729	136.804
64 01D	SOLAR RAD	00730	136.887
64 03A	Relay 2	00737	136C620 136C142
64 04A	Echo 2	00740	136.021 136.170
64 06A	Elektron 1	00746	20C005 30C008
64 06B	Elektron 2	00748	19C430 19C540 90C225
64 15A	Ariel 2	00771	136.557
64 19B	Polyot 2	00784	19.895
64 26A		00801	150C0 400C0
64 40C		00838	136.771
64 51A	Expl. 20	00870	1.5 2.0 2.850 3.720 5.470 7.220 136C326 136C350 136C680
64 52A	Nimbus 1	00872	136.499
64 53A	Cosmos 44	00876	90C023
64 54A	OGO 1	00879	136.200
64 60A	Expl. 21	00889	136.146
64 64A	Expl. 22	00899	20C005 40C010 160C0 324C0 360C09
64 74A	Expl. 23	00924	136C079 136.858
64 76A	Expl. 24	00931	136.709
64 76B	Expl. 25	00932	136.293 136C860
64 83C		00959	136.561
64 84A	San Marco	00957	136C53 136.74
64 86A	Expl. 26	00963	136.273
65 04A	Tiros 9	00978	136.231 136.919
65 07A	Orb.Sol.Ob2	00987	136.712
65 09A	Pegasus 1	01085	136C410 136.890
65 16B	Gr.Grad II	01244	136.742
65 16C	Gr.Grad III	01292	136.767
65 16D	Solar Rad.	01291	136.800
65 16E	EGRS III	01208	136.841
65 16F	OSCAR III	01293	145.95 CW Beacon 145.85 Cont.Tele. 145.90 Repeater
65 17B	EGRS II	01250	136.838
65 27B	EGRS IV	01315	136.840

EXHIBIT I



Society of Photographic Scientists & Engineers
P.O. Box 1609, Main Post Office, Washington, D. C. 20013

Co-Sponsor
Systems Engineering Group
Research and Technology Division
U.S. Air Force Systems Command

Appointments

Monday

Tuesday

Wednesday

Thursday

Friday

President's Welcome

Welcome to the 1965 Conference of the Society of Photographic Scientists and Engineers. Speaking on behalf of the Society and its Chapters, the Board of Directors, and the Conference Committees, I would like to welcome you to Cleveland. I sincerely hope that you will find this Conference both informative and enjoyable. Represented at this SPSE Conference are some of the outstanding authorities and manufacturers in the field of photographic science and engineering all over the world. You will have the opportunity to hear about and explore some of the many products, processes, and practices which serve the photographic community today.

For those of you participating in our Society's activities for the first time, I would like to give you some information about the Society of Photographic Scientists and Engineers. The SPSE considers its area of responsibility to be basic photographic science and engineering as well as applications in those fields. Major activities of the Society include not only an Annual Conference and an Annual Symposium, but many outstanding publications. Included are the *Journal of Photographic Science and Engineering*, the *SPSE News*, and the *Abstracts of Photographic Science and Engineering Literature.* The *SPSE Journal* and the *SPSE News* are sent to all members of SPSE as a part of their membership.

Additional information about Society membership may be obtained at the registration desk or from any of the present Society officers or members. I hope that this Conference will be a rewarding experience for you.

Sincerely,

R. E. Birr
President

Additional information and membership applications can be obtained at the Conference Registration desk or by writing to the Society's headquarters:

Society of Photographic Scientists and Engineers

Box 1609, Main Post Office, Washington, D. C.

Calendar of Events*

Sunday, May 16th

1:30 PM	**Board of Director's Meeting** (Terminal Room)
6 PM to 10 PM	**Registration***
Evening	**Get Acquainted Buffet**

Monday, May 17th

8 AM to 5 PM	**Registration***
9 AM to 12 Noon	**Papers:*** *Photography in Earth Reconnaissance*
12:30 PM to 2 PM	**Welcoming Luncheon** (Cleveland Room) *Guest Speaker:* Brig. Gen. Y. A. Yancey, AFR
2 PM to 5 PM	**Papers:*** *Photographic Systems in Earth and Space Reconnaissance* **Panel Discussion:*** *Stabilization of Satellite-Borne Reconnaissance Systems*
8:15 PM to 10 PM	**Papers:*** *The Information Copy Revolution and Its Problems*

Tuesday, May 18th

8 AM to 5 PM	**Registration***
9 AM to 12:30 PM	**Papers:*** *Image Evaluation*
2 PM to 2:45 PM	**Papers:*** *Image Evaluation (Continued)*
2:45 PM to 3:45 PM	**Panel Discussion:*** *Education for Photographic Engineering from the Engineer's Viewpoint*
3:45 PM to 5:30 PM	**Papers:*** *Medical Photography*
7 PM	**Tour:** *G. E. Lighting Institute—Nela Park*

Wednesday, May 19th

8 AM to 5 PM	**Registration***
9 AM to 12 Noon	**Papers:*** *Lasers in Photography*
12:30 PM	**Chapter Presidents' Luncheon** (Navahoe Room)
2 PM to 5:30 PM	**Papers:*** *Unconventional Photographic Systems*
6 PM to 7:30 PM	**Social Hour** (Gold Room)

* *Registration*—Mezzanine
Papers Sessions and Panel Discussions—Gold Room
SPSE Office—East Room
Press Room—Director's Room

Calendar of Events*

Thursday, May 20th

8 AM to 5 PM	**Registration***
9 AM to 12 Noon	**Papers:*** *Rapid Processing*
2 PM to 5 PM	**Papers:*** *Image Formation and Manipulation*
6:30 PM to 7:30 PM	**Assembly A—Cash Bar**
7:30 PM	**SPSE Annual Banquet** (Gold Room)

Friday, May 21st

8 AM to 12 Noon	**Registration***
9 AM to 12 Noon	**Papers:*** *Further New Theory, Mechanisms, and Materials*
2 PM to 4 PM	**Papers:*** *Engineering Exhibits Presentations*

* *Registration*—Mezzanine
Papers Sessions and Panel Discussions—Gold Room
SPSE Office—East Room
Press Room—Director's Room

Exhibit Schedule

(Whitehall Room)

Monday, May 17th	6 PM to 8 PM
Tuesday, May 18th	11 AM to 5 PM
Wednesday, May 19th	11 AM to 5 PM
Thursday, May 20th	11 AM to 5 PM

Memos

Schedule of Papers

Monday Morning, May 17th

Photography in Earth Reconnaissance

Session Chairman: R. G. TARKINGTON

1 **The Chromatic Characteristics of Additive Color Aerial Photography,** E. YOST AND S. WENDEROTH, *Fairchild Camera and Instrument Corporation, Robbins Lane, Syosset, Long Island, N.Y.*

The chromatic accuracy obtainable from color aerial photography taken using the additive color principle is discussed. Additive color aerial photography is obtained by the simultaneous imaging of reflected electromagnetic radiation from the terrain through selected filters on a suitable achromatic recording medium. Practically, this involves the simultaneous exposure of a number of spatially identical, filtered photographs on a silver halide emulsion. When such photographs are projected through a linear compensation of the taking filters, the superimposed image is seen in color. The accuracy of the color representation of the scene referenced to a given standard is dependent on a number of factors which include: the filter–lens–emulsion combination in the taking camera; the accuracy with which the characteristic curves of the individual photographs can be imaged in processing; the chromatic light scattering effects of the projecting system; as well as variations in the spectral quality of the scene illuminant and the variable attenuation of the atmosphere. The relationship of object color in the scene to image color, as viewed by an observer, will be presented in terms of I.C.E. chromaticity coordinates. These coordinates are computed from spectrophotometric data using the weighted ordinate method. The effect of lens–filter interaction with panchromatic and nonuniform spectral sensitivity emulsions will be analyzed. Compensation for chromatic inaccuracies in viewing due to the previously mentioned effects can be partially adjusted for the entire scene by variation of the hue, brightness, and saturation of the image. The extent to which this correction can be accomplished will be demonstrated.

2 **Films and Plates for Aerial Color Photography,** ALLAN L. SOREM, JAMES S. MOSER, AND J. MASON BURNHAM, *Research Laboratories, Eastman Kodak Company, Rochester, N.Y. 14650*

The different requirements of high- and low-altitude aerial reconnaissance, mapping, coast and geodetic, geo-

logical, and agricultural surveys, and other applications of aerial color photography, can be met by selecting a film having a suitable combination of speed, contrast, and definition from several Kodak aerial color materials now available. These include a high-speed, medium-gamma film for low-altitude reconnaissance, a duplicating film, and reversal color diapositive plates for use in first-order plotters. Integrated systems for aerial color photography are discussed, and information is presented about the sensitometric, image structure, and processing characteristics of Kodak aerial color films and a color diapositive plate.

3 **The Change of Aerial Camera Exposure with Solar Altitude,** M. R. SPECHT, N. L. FRITZ, AND A. L. SOREM, *Research Laboratories, Eastman Kodak Company, Rochester, N.Y. 14650*

The relationship between solar altitude and apparent scene luminance for aerial photography has been determined by the evaluation of a series of aerial photographs made of specific scenes at solar altitudes ranging from 68 to $-1°$. Variations, as a function of solar altitude, in the apparent luminances of individual details, as well as in luminance distributions, were obtained from microdensitometer measurements on the negatives. The results are compared to the curves relating solar altitude with illuminance on a horizontal plane and with Jones' and Condit's luminous density. Significant differences among these relationships are noted.

4 **Luminance Distributions in Aerial Scenes,** A. L. SOREM, N. L. FRITZ, AND M. R. SPECHT, *Research Laboratories, Eastman Kodak Company, Rochester, N.Y. 14650*

The distributions of the apparent luminances of representative aerial scenes have been determined from photographs made at five altitudes from 1000 to 16,000 ft. In each test, the apparent luminances of 5000 2-ft-diameter areas were measured by microdensitometer readings on the negatives. Test variables included haze, solar altitudes, and effective film spectral sensitivities. The data will assist in determining camera exposures and exposure latitudes required for maximum quality in both low- and high-altitude aerial photography.

5 **Phase Angle and the Brightness of Objects,** VICTOR J. SLABINSKI, *Case Institute of Technology, Cleveland, Ohio*

Whether or not a photographic trace of a sunlit artificial earth satellite can be obtained under stated conditions

may depend on the phase angle between the direction in which the object is viewed and the direction of the illumination. Satisfactory prediction of apparent brightness requires that the effect of phase angle be calculated. The classical formulae attributed to Euler and to Lambert are shown to be in poor agreement. Observed variations in brightness of artificial earth satellites attributable to phase angle are evaluated.

6 **A Program for Cataloguing Reports on Apparent Satellite Brightness,** THOMAS W. PETRIE, *Andrew Jennings Computing Center, Case Institute of Technology, Cleveland, Ohio*

A computer program is described to which the inputs are mean orbital elements of an identified satellite, station coordinates, coordinates and brightness of a companion star, and apparent relative brightness. The program outputs: (1) a letter to the observer confirming (or denying) the identification and reducing the reported brightness to normalized viewing conditions; applying the equations of Euler, Lambert, and sin ½ elongation angle; and (2) a merger of the reduced data in a catalog of such reports on all satellites.

7 **Modulation Transfer Characteristics of Water of Controlled Turbidity,** G. G. FULMER AND H. M. GREENBERG, *School of Photography, Rochester Institute of Technology, Rochester, N.Y.*

A sinusoidal object was photographed through a specially constructed tank containing turbid water. The changes in modulation at varying spatial frequencies and image contrast were evaluated for several levels of turbidity. The controlled turbidity, produced by a calcium oxalate suspension, is specified by three independent measurements: nephelometry, photometric transmittance, and concentration expressed as PPM. Data have been obtained indicating the relationship between the amount of turbidity present and the change in image contrast at varying spatial frequencies, or MTF.

Monday Afternoon, May 17th

Photographic Systems in Earth and Space Reconnaissance

Session Chairman: NORTON GOODWIN

8 **Characteristics of Image Motions in Aerial Cameras,** EARLE B. BROWN, *The Perkin-Elmer Corporation, Norwalk, Conn.*

Image motions in aerial cameras result from apparent ground motion due to vehicle forward velocity and also from camera and vehicle angular motions. Their magnitude and direction depend upon directions of camera pointing as well as upon vehicle velocity and altitude. These motions have been analyzed as functions of position in the camera focal plane, and divided into components in longitudinal and lateral directions. There are five distinct patterns of motion in each direction. The simple first-order terms are well known and are corrected by conventional techniques. The second order terms which arise when oblique pointings are involved are of interest in high-performance applications, and will call for new techniques of compensation. The nature of the five patterns is described and the conditions for their occurrence are identified.

9 **Electronic Image Motion Stabilization,** EFRAIM R. ARAZI, *Itek Corporation, Lexington, Mass.*

A technique has been developed that enables photographing scenes that move or vibrate with respect to the camera. This situation arises when cameras or telescopes are subjected to vibration and when the object to be observed moves or vibrates. Essentially the technique involves conversion of the object optical image into an electron stream. The electron stream is converted back to an optical image on a phosphor screen. When the image is in the electron stream state, it can be moved in two dimensions by means of electromagnetic fields generated by deflection coils. Two systems are described: (1) The position of the image on the phosphor screen is sensed by an electro-optical sensor whose output is fed to the deflection coils. This feedback system strives to stabilize the output image at a null location, at all times independent of the motion or vibration of the input image. It is particularly useful in photography of planets, the moon, or objects in space in the presence of a scintillation or telescope vibration. (2) The motion of the complete camera is sensed by inertial sensors which control the deflection coils. This is suitable for aerial cameras and hand-held telescopes or movie (TV) cameras. Proto-

types of both system, and initial results obtained in lunar and planet photography will be demonstrated.

10 **Atmospheric Shimmer and Its Effects upon Astrometric Photography of Celestial Objects as Observed with a Ground-Based, Telescope-Camera System,** ROBERT H. WEITBRECHT, *Stanford Research Institute, Menlo Park, Calif.*

This paper describes some results that have accrued from several years of experience with an automatically guided astrometric camera on the 36-in. refractor telescope at Lick Observatory. Specifically, the question of image quality is explored. Various extrinsic factors such as seeing and guidance accuracy are considered. Experiments with a system of photography for obtaining high-definition photographs of the balloon satellite, ECHO I, are described, and results are shown. Because of atmospheric shimmer, as well as photographic peculiarities resulting from specular reflection of sunlight off the object's surface, this NASA-supported work was not successful. This problem is discussed in some detail.

Panel Discussion: Stabilization of Satellite-Borne Reconnaissance Systems

11 **Photographic and Television Observation of the Erection of Large Structures in Space,** DONALD P. ROGERS, *National Aeronautics and Space Administration, Washington, D.C.*

Several large structures have been erected in space—ECHO I and II and Pegasus I. Since these structures were so designed as to preclude realistic ground testing of their erection behavior in a 1-g environment, and since ground observation would be inadequate to record their erection in space with sufficient detail, spaceborne photographic and television systems were developed and used for this purpose. These systems along with required stabilization systems are described and film clips are shown of the erection in space of the two ECHO ballistic tests, the ECHO II orbital deployment, and the Pegasus unfolding.

12 **Active Stabilization of Satellite-Borne Sensors for Meteorology,** H. I. BUTLER, *Aeronomy and Meteorology Division, Goddard Space Flight Center, Greenbelt, Md.*

For meteorological purposes, two types of stabilization systems are being employed; one in which the attitude of

the spacecraft is controlled by a three-axis, active control system and the second in which the spacecraft spins (10 rpm) to provide the stability of a gyroscopic body. Simple camera and line–scan sensor systems can be readily accommodated on spinning spacecraft. However, the more advanced sensor systems which are capable of higher spatial or spectral resolution or increased sensitivity for night observation require the stability provided by the three-axis type of control system.

13 Passive Stabilization of Earth Orbiting Satellites, HENRY C. HOFFMAN, *Space Craft Systems Projects Division, Goddard Space Flight Center, Greenbelt, Md.*

Parts of an object in a free-fall system are subjected to minutely different gravitational forces. The gravitational gradient can be utilized in stabilizing an object so that it always projects the same aspect to the gravitational center of the system. Extension of the theory suggests the possibility of obtaining passive stabilization around the vertical axis also. Feasibility of passive satellite stabilization in earth reconnaissance systems is considered. Passive stabilization features of the Applied Technology Satellite (ATS) are described. The state-of-the-art in passive satellite stabilization is discussed. A review will be made of the disturbances encountered by gravity gradient satellites. These include eccentricity and aerodynamic, magnetic, and solar disturbances. Typical satellite libration curves will be presented.

13a Stabilization of Ranger and Mariner Reconnaissance Systems, GERALD W. MEISENHOLDER, *Jet Propulsion Laboratory, California Institute of Technology,* 4800 *Oak Grove Dr., Pasadena, Calif.*

Deep space, lunar, and planetary scientific spacecraft have been developed utilizing full three-axis attitude control. Celestial references of either Sun–Earth or Sun–Canopus are maintained by pulsing small cold gas nozzles when angular deviations from the references exceed approximately ¼ degree. Operating in such a limit cycle mode, the vehicle itself becomes a stable platform from which to perform photographic and scientific experiments.

Monday Evening, May 17th

The Information Copy Revolution and Its Problems

Session Chairman: LOUIS ROSENBLUM

14 *Invited Paper:* **Selective Dissemination of Information at NASA,** GIFFORD A. YOUNG, *Scientific andTechnical Information Division, NASA, Washington, D.C.*

15 *Invited Paper:* **Information Processing Systems and Copyright Legislation,** NORTON GOODWIN, *Independent Tracking Coordination Program, SPSE, Washington, D.C.*

The current role of technical librarians as "leaks" in the classical copyright system is considered. The constitutional authority to "Promote the Progress of Science and Useful Arts. ." through copyright legislation is evaluated in the terms of current data storage, search, retrieval, reproduction, and transmitting systems, in all of which copying is of the essence. A set of legislative objectives is proposed, designed to encourage the commercial availability of data files in technical format on which a fixed reproduction fee would be the financial motivation, and in which periodic listing of the number of reproductions on each reproduced data file would be a byproduct. The value of frequency-of-use data in purging rapid-access data files is discussed. The case of compulsory licensing for "juke boxes" is noted and distinguished.

Tuesday Morning, May 18th

Image Evaluation

Session Chairman: WILLIAM S. SHOEMAKER

16 *Invited Paper:* **A Review of Current Image Evaluation Techniques,** G. C. BROCK, *Itek Corporation, Lexington, Mass.*

Spatial frequency analysis provides a valuable tool for photo-optical research and system design, but does not indicate quality in terms that relate directly to images as seen. Hence, resolving-power remains in use in spite of its failings. The paper criticizes the desire for a single-number, quality index, and discusses the significance of resolving-power, transfer function, single bar and acutance tests. It points out that the time is ripe for abandoning 3-bar, resolving-power in favor of specialized tests employing a frequency basis where appropriate in analysis or development, but a size or spatial base for expressing system performance.

17 **Variations of SMT Acutance with System Parameters,** M. C. GODDARD AND R. G. GENDRON, *Research Laboratories, Eastman Kodak Company, Rochester, N.Y.*

Crane (1964) gave an empirical formula for SMT acutance

$$120\text{–}25 \log \sum_{i} (200 \times \text{magnification/MTC area}_i)^2$$

In this formula, the subscript "i" refers to the elements of a photographic system from the camera's lens to the observer's eye. The rates at which changes in the MTC areas and magnification contribute to changes in SMT acutance are examined. These rates provide a measure of the relative sensitivity of SMT acutance to changes in the system elements. Examples are drawn from an 8-mm color system and a color print system.

18 **Variation of MTC Area with Characteristics of Modulation Transfer Functions for Color Films,** R. G. GENDRON AND M. C. GODDARD, *Research Laboratories, Eastman Kodak Company, Rochester, N.Y.*

Three characteristic vectors have been found that accurately represent the various shapes of the modulation transfer curves for a variety of color films. Certain scalar

amounts of these characteristic vectors will match the original MT curves closely. A linear combination of the scalars will also predict the MTC area. Since the rates of change in SMT acutance for a photographic system can be related to changes in MTC area, the rates of acutance changes can now also be connected more directly to the MT curves.

19 **MTF Measurement by Using a Spatial Frequency Target Generator,** TIMOTHY TROTT, *Newtek, Inc., Woodside, N.Y.*

A new type target for evaluating the MTF of photographic systems is described. This unconventional target provides a continuously variable range of spatial frequencies whose intensity is a sinusoidal function of the space coordinate. By using this target generator, together with light source, collimator, test bench, and recorder, it is possible to obtain the MTF of the photographic system. A description of the target generator will be given together with the range of resolution, aperture, focal length and field angles, over which measurements can be performed.

20 **Three-Bar Target Modulation Detectability,** FRANK SCOTT, *Perkin-Elmer Corporation, Wilton, Conn.*

A function relating spatial frequency to the minimum three-bar resolution target image modulation required for resolution is useful in photo-optical system design and evaluation. Using modulation detectability curves, the resolving power of a system can be predicted from its modulation transfer function. The methods used to measure the modulation detectability of several aerial films and examples of the use of modulation detectability curves are presented.

21 **The Production of Photographic Edges of Extreme Sharpness,** C. S. MCCAMY AND M. A. BERKOVITZ, *National Bureau of Standards, Washington, D.C.*

A method of producing sharp photographic edges of high quality has been developed. The method involves contact printing a piece of thin metal foil with a very fine-grain film and exposing with soft x-rays. The procedure used to obtain a very sharp and straight edge on one side of the thin foil is discussed. Several other experiments that were attempted but produced edges of lesser quality are briefly described.

22 The Production of Variable-Transmission Sinusoidal Patterns and Other Images, FRANK SCOTT, *Perkin-Elmer Corporation, Wilton, Conn.*

A method is described for producing variable-transmission images such as sine-wave patterns and spatial filters. Images of variable-area patterns designed to compensate for the nonlinear response of photosensitive materials and the modulation transfer functions involved in the process are linearly or curvilinearly smeared using simple devices. Essentially grainless, sinusoidally varying transmission patterns of high spatial frequency, with modulation values of nearly 1.0 and with little harmonic distortion have been made. The procedure is not limited to any specific photosensitive material. Where the variable-transmission image is used with a nonlinearly responding detector, compensation can be achieved for detector response.

Tuesday Afternoon, May 18th

Image Evaluation, Continued

Session Chairman: WILLIAM S. SHOEMAKER

23 **The Effect of Slit Misalignment on the MTF of the Microdensitometer,** ROBERT A. JONES, *The Perkin-Elmer Corporation, Norwalk, Conn.*

An analysis is made of the degradation that occurs in the MTF of a microdensitometer as a result of imperfect alignment between the slit of the microdensitometer and the edge of the image being traced. Alterations in the MTF of the microdensitometer are predicted as a function of angular misalignment, slit length to width ratio, and the effective slit width. The values of the misalignment angle are correlated with the values of the resulting fractional errors in the MTF of the microdensitometer.

24 **A Systematic Notation for Optical Density,** CALVIN S. MCCAMY, *National Bureau of Standards, Washington, D.C.*

The measured density of a sample depends upon the geometrical distribution of the incident flux, the geometrical nature of the system which evaluates the flux, the spectral quality of incident flux, and the spectral characteristics of the system which evaluates the flux. These facts may be expressed in functional notation in the form $D(g, g'; s, s')$, where the independent variables refer to the above factors. These variables may be given numerical values under most circumstances and, by standardization, all cases can be adequately described. The notation is simpler, more easily generalized, and more nearly self-explanatory than existing standard notation. Standardization of the notation is recommended.

Education in Photography

Panel Discussion: Education for Photographic Engineering from the Engineer's Viewpoint

25 **Discussion Leader:** HOLLIS N. TODD
Panelists: MAX BEARD, *U.S. Naval Ordnance Laboratory, White Oak, Silver Spring, Md.;* RONALD COLLINS, *3M Company, St. Paul, Minn.;* C. S. MCCAMY, *National Bureau of Standards, Washington, D.C.;* ROBERT KOHLER, *Itek Corporation, Lexington, Mass.*

Medical Photography

Session Chairman: JULIUS WEBER

26 **High Speed X-Ray Motion Picture Photography of Internal Heart Structures** DR. F. M. SONES, JR., *Cleveland Clinic Foundation, Cleveland, Ohio*

In the diagnosis of heart disease, high-speed x-ray motion pictures of internal heart structure are taken, with image amplification, on a fluoroscopic screen. Electrocardiograms are taken simultaneously as controls. Individual frames of the motion pictures are enlarged and printed; abnormalities are then studied with their help. Special stereo x-ray motion picture studies will be demonstrated.

27 **The Recording of Dynamic Events in Organs of Living Animals at the Microscopic Level,** EDWARD H. BLOCH, *Department of Anatomy, Western Reserve University, 2019 Adelbert Rd., Cleveland, Ohio*

A motion picture film will illustrate the progress that is being made to establish the cellular structure of organs in living animals by recording their microscopic images directly on motion picture film as well as by translating these optical images into electronic images and then recording these images. The film will depict the use of high-speed cinemicrography for analyzing the cellular flow pattern in small arteries and veins. The goal of these studies is to secure quantitative morphological and biochemical data at the cellular level of major organs like the lung, liver, and kidney. Small animals were anesthetized, the organ exposed, and then transilluminated with monochromatic light at wavelengths between 405 and 650 μ. The organs were examined at magnifications ranging between 500 and 1500 $\times$. The images were either recorded directly on Kodachrome Type II film or on Tri-X film from a video monitor. Optical and electronic images were secured with details commensurate with and limited by the optics of the light microscope. The technical problems will be discussed in regard to illumination, high-speed recording, and films.

28 **A Proposed Colored Radiographic System For Radiodontics,** JAMES A. LANGONE, RAYMOND EYNARD, AND J. SCOTT WILSON, *Rochester Institute of Technology, Rochester, N.Y.*

A color radiographic system is proposed to obtain colored representations for varying densities of subject material by using a tripack of three nonscreen x-ray films of

varying speed and by using dye-coupling development and reversal techniques where necessary. An investigation was carried out to demonstrate the feasibility of obtaining such a colored radiograph of subject material normally encountered in the field of radiodontics. Full-mouth, colored radiographs were attained using the proposed system with a tripack composed of three sheets of Ultra-Speed dental x-ray film and exposed by conventional radiodontic techniques.

29 **New Nikon Francon-Yamamoto Differential Interference Microscopes,** BERNARD FRIEDMAN, *Instrument Division of Nikon Inc., 109–111 Fifth Ave., New York, N.Y.,* AND JULIUS WEBER, *Beth Israel, Fordham, Misericordia, and Morrisania Hospitals, New York, N.Y.*

Two new polarization interference microscopes based on the differential method have been recently designed by M. Francon and T. Yamamoto, one for transmittance and one for reflected light. The design is based on the employment of Savart polariscopes between crossed polars. Examples of their use in biological and industrial research will be discussed and demonstrated.

30 **A Study of Lead Monoxide as a Medium for Medical X-Ray Electrophotography,** EUGENE S. ANOLICK, *General Electric Company, Chemical Development Operation, Pittsfield, Mass.*

The possibility of developing a high-speed, x-ray plate consisting of a film of powdered lead monoxide bound in an organic resin has been investigated. The use of lead monoxide was based on its absorption of x-rays and the known photoconductivity of the compound. A goal of ten times the speed of industrial selenium Xeroradiographic plates was set; a speed of four times that of selenium was obtained as determined by voltage measurements. The PbO source, resin, grinding, and heat treatment were found to have a direct influence on the measured speed.

Wednesday Morning, May 19th

Lasers in Photography

Session Chairman: JEROME S. GOLDHAMMER

31 *Invited Paper:* **Technical Applications of Optical Masers,** J. S. COURTNEY-PRATT, *Bell Laboratories, Murray Hill, N.J.*

32 **Spatial Filtering Experiments with Laser Illumination,** JOHN HOLEMAN, *General Electric Company, Advanced Technology Laboratory, Schenectady, N.Y.*

The invention of the gas laser makes practical the process known as a spatial filtering which can be used either to enhance any particular kind of information in a photograph or to extract this information. This makes it possible to mechanically recognize characters or objects at high speeds and under conditions which would tax human ability. Examples will be given of objects extracted from photographs under different conditions of contrast, size, and so forth.

33 **Enhancement of Weak Photographic Images by Coherent Optical Processing,** JOHN F. FORKNER AND JAMES W. JEWITT, *Aeronutronic Division of Philco Corporation, Newport Beach, Calif.*

A coherent optical technique for extracting weak image from background noise is described. Separately exposed negatives are assembled in a regular array; the similar array formed by the objects of interest has a spatial frequency spectrum sufficiently distinct from that of the noise background that a spatial filter can block much of the background energy. Ideally, the contrast of the image reconstructed after filtering will equal the number of photographs, N, used. This represents a significant gain over the $\sqrt{N}$ factor obtainable by superposition of weak negatives, a noncoherent enhancement technique often used.

34 **Laser Mapping Applications,** JOHN H. ATKINSON, JR., GLEN W. CHAPMAN, JULIUS C. GECSY, AND CHARLES W. SEAMER, *Aeronutronic Division of Philco Corporation, Newport Beach, Calif.*

A laser ranger can furnish the metric mapping required for aerotriangulation and elevation determination. Aerotriangulation requirements are best met by a fixed

geometry of spots projected on the surface at the six classical positions. Simultaneous photography of these laser spots on the prime exposure makes the system self-spotting and self-calibrating. Elevation determinations are best made by ranging to a large number of points. Ranging and spot photography present somewhat contradictory requirements for high power in a short pulse and high integrated energy respectively. Hybrid modulation techniques have been investigated with some resulting reciprocity failure data.

35 Lunar Reconnaissance Landing Aid, JOHN H. ATKINSON, JR. AND WILLIS D. MARSING, *Aeronutronic Division of Philco Corporation, Newport Beach, Calif.*

Aeronutronic suggests the use of a lightweight reconnaissance package as a landing aid for the early Apollo landing missions. Use of this package will give the astronauts topographic information progressing in accuracy from the order of kilometers available from earth to the order of dekameters from an 80-naut mi orbit to the order of meters from a 50,000-ft orbit. This information is presented on a timely basis in the form of stereo photography with overlaid contours and grid lines. This information can be used for successively finer site selection on the actual landing mission. During the actual landing, the same equipment can be used to give increasingly accurate meter readings of forward and cross slope and altitude with the camera providing documentary coverage.

36 Photographing Laser Illuminated Satellites for Geodetic Purposes, MICHAEL S. TAVENNER AND ROBERT L. ILIFF, *Terrestrial Sciences Laboraoratory, Air Force Cambridge Research Laboratories, Bedford, Mass.*

On January 21, 1965, an optical signal was transmitted from a ground station, reflected from an artificial satellite, and recorded both as a photographic image and as an electrical pulse from a photomultiplier tube. The transmitting equipment was a ruby laser with 250 joules output energy, 15-arc-min collimated beamwidth, and a 2.7 ms pulse duration. The receiving camera was a PC-1000 Ballistic Camera of 40-in. focal length, $f/5$ lens. The photographic image was about 50 μ in diameter and was recorded on a Kodak "Micro-flat" glass plate with 103F emulsion. The receiving photodetector used a 5-in. collecting lens and a 9558B EMI photomultiplier tube as the sensor. Effective size of the satellite reflector,

made of small corner cube reflectors, was about 100 cm^2 and the range was 1491 km as determined by independent tracking methods. A short history is given of the present state of development of this system at AFCRL, illustrating the need for improved stellar stereo-triangulation methods. Azimuth, elevation, and range can be obtained from a single observation, thus determining a passive satellite's position uniquely from one observing station.

Wednesday Afternoon, May 19th

Unconventional Photographic Systems

Session Chairman: JAROMIR KOSAR

37 **Evaluation of Zinc Oxide-Coated Electrophotographic Papers,** A. KAHN, C. T. RANDOLPH, AND T. M. CRAWFORD, *IBM Corporation, Los Gatos, Calif.*

In an application in which the amount of available light was limited, it was desired to determine the potential usefulness of zinc oxide-coated, electrophotographic paper without actual performance testing. The spectral characteristics of a number of zinc oxide-coated papers were obtained, and the effective utilization of the light from a specific light source was determined. Calculations were then made of the effective quantum yield of the papers.

38 **Noise on Electrofax Paper,** D. W. SEYMOUR, *Phillip A. Hunt Chemical Corporation, Palisades Park, N.J.*

Observations made with a small electrometer probe in close proximity to negatively-charged, zinc oxide-coated paper reveal local spatial fluctuations of the charge acceptance voltage of the order of twenty percent. The noisy charge distribution thus indicated results in highly divergent field patterns which, in turn, give rise to stronger dipole forces than formerly suspected. The noise is observed to decay slowly on exposure, leaving appreciable noise residue related to background. Examples are given of liquid toners for which forces on dipoles [dielectrophoresis] dominate the coulomb forces [electrophoresis] in the mechanism of image development.

39 **X-Ray Induced Discharge of Selenium Xerographic Plates,** J. NEYHART AND J. SCHOTTMILLER, *Xerox Corporation, 611 Holland St., Rochester, N.Y.*

The initial rate of loss of surface charge by exposure to ionizing radiation is a measure of the speed of selenium xerographic plates. The initial discharge slope, dQ/dt, was measured as a function of selenium thickness, applied field, range of charge carriers, and x-ray tube kilovoltage and filtering. The slope was roughly proportional to thickness for thin films and independent of thickness for thick films. It rose with applied field and did not completely saturate at high fields, suggesting that appreciable secondary photocurrents were present in the xerographic mode of operation. The initial slope also increased with hole and electron trapping ranges in a

qualitatively predictable way. Finally, the hardness of the radiation, determined by the kilovoltage and filtering, affected the discharge rate by varying the region in the film in which the charge carriers were produced.

40 **The Application of Gain Photoconductors to Charge Transfer Frost Xerography,** M. SMITH AND A. BEHRINGER, *Xerox Corporation, 611 Holland St., Rochester, N.Y.*

A new photographic method was recently reported in which an electrostatic latent image is transferred to a thermoplastic film which is then heat treated to create a deformation image. The feasibility of an improvement in the photographic speed of this system via the use of a one-carrier, trapping-type photoreceptor has been investigated. CdS layers showing high quantum gain and acceptable dark currents were prepared. Image development in the complete system was demonstrated with these layers. The moderate performance was attributed to variations in the oil coupling layer thickness caused by surface roughness. Present investigations with evaporated CdS films will be described.

41 **Photocharge Recording Process,** JOSEPH GAYNOR AND GORDON J. SEWELL, *Advanced Technology Laboratories, General Electric Company, Schenectady, N.Y.*

A new, grainless, dry, high-resolution, instant-development, photosensitive recording process is described. It is based on a "photovoltaic" mechanism. When thin deformable polymeric films containing a photochargeable material are exposed to a light image and then quickly heated, the films deform wherever incident photons have been absorbed. No prior sensitization to light is required. Reheating to a temperature higher than that employed for development erases the image and reuse is possible. A tentative mechanism to explain the photon-induced generation of electrical fields high enough to produce deformation will be discussed. Development and erasure characteristics, spectral response and characteristic curves which show sensitivity and gamma will be presented.

42 **Red Sensitive Photoplastic Recording Film,** JOHN J. BARTFAI, VERNON OZAROW AND JOSEPH GAYNOR, *Advanced Technology Laboratories, General Electric Company, Schenectady, N.Y.*

Photoplastic Recording Film has its main spectral sensitivity in the blue and near ultraviolet. The films to be described here possess photoconductive response through-

out the visible and near infrared with a peak in the 5000–7000 Å band. The sensitivity of the film as a photographic element was measured by the Modulation Efficiency Method developed for this type of film, using radiation in the aforementioned band. The sensitivity criterion of 1% Modulation Efficiency was attained with exposures of 0.03–7.0 μjoules/cm^2. (Obtained by extrapolation of measured values at 1–50 μjoules/cm^2.) The films were charged to give fields across them of 20–40 v/μ. Data will be presented describing the spectral dependence of the films' photo-induced decay characteristics as functions of exposure and field. Photographs taken with the film will be shown.

43 WITHDRAWN BY THE AUTHORS.

44 **Third Dimension with Additive Color System for Motion Pictures,** FRANCIS A. PALL, *General Dynamics/Astronautics, San Diego, Calif.*

The combination of the oldest principle of color theory and the latest development in optical science has been designed into a new, motion picture, additive color system. The camera is of conventional design. The film is standard black-and-white panchromatic. The projection is with normal frequency and single frame advancement. Unlike the conventional motion picture projection, in this system each frame will be projected three times, once from three different positions. The three adjacent full-size frames are simultaneously projected in one projector through three lenses plus three color filters. With this system, the full-size frame is used for the first time in additive color motion picture projection, and the third dimensional color picture becomes a reality. The natural living colors, produced by this design will result in a new "three dimension," which becomes so real that one has a participating experience which is typical of a live theater performance, rather than a movie film observation.

Thursday Morning, May 20th

Rapid Processing

Session Chairman: GORDON O. F. JOHNSON

45 **Ultrasonic Agitation of a Developer,** CHARLES L. SCAVRON AND EDWARD KOB, *Rochester Institute of Technology, Rochester, N.Y.*

The effects of ultrasonics during processing of photographic film were: an increase in speed and gamma; no change in fog; no change in developer temperature in either the emulsion layer or at the film surface; an increased fixing rate. These effects are attributed to local pressure changes during a resonant condition which increase solution diffusion rate at the film surface.

46 **A Compact, Rapid-Access Wide Film and Paper Processor,** HOWARD W. HOADLEY, *Houston Fearless Corporation, 11801 W. Olympic Blvd., Los Angeles, Calif. 90064*

The development of an experimental, continuous processing machine, the EH-52, is described. The processor applies high-temperature developer and lower-temperature fixer on sensitized materials up to 9½ in. wide, transported by a vacuum capstan. The daylight–darkroom machine is housed in 20 × 36 × 36-in., Type 316, stainless-steel honeycomb cabinet that provides structural integrity and thermal and acoustic insulation.

47 **70-mm Film Processor for Airborne Application,** ROBERT BUCKINGHAM AND ALAN MILLER, *Chicago Aerial Industries, Inc., Barrington, Ill.*

The processor, developed under contract for the U.S. Army Electronics Research and Development Laboratories, Ft. Monmouth, N.J., and designated EH-51, is an airborne 70-mm film processor which operates at continuously variable film rates from ½ to 75 ft/min while providing a constant image access time of 12 sec. The processor has five principal innovations in operation: (1) the use of continuous liquid monobath processing of 500 ft of 70-mm film; (2) the method of processing by a unique free-loop immersion of the film in the monobath without internal rollers, elevators, and guides; (3) continuously variable and accurately controlled film drive over a velocity range of 150 to 1; (4) a specially developed liquid seal permitting operation in any attitude while transporting and processing film; and (5) small size and weight as compared to conventional free-liquid systems.

48 **A New Film–Monobath Combination for Oscillography,** W. J. MORETTI, D. G. BUSHMAN, AND J. C. BARNES, *Research Laboratories, Eastman Kodak Company, Rochester, N.Y. 14650*

A film process has been designed for use in oscillography and in related applications where in-line processing at variable rates is a desirable feature. A new film, Kodak RAR Film, Type 2490, has been specifically designed for high-temperature monobath processing, and a new monobath, MX-448-3, has been specifically designed to simultaneously develop and clear this film in 30 sec at approximately 100°F. Unusually broad latitude with respect to temperature, time, and agitation characterize the process, but it is vital that the mechanical component required to provide a complete processing system be designed with attention to the rather special characteristics of this new film–process combination.

49 **Rapid Access Processing of Cathode-Ray Tube Recording Films,** J. C. BARNES, *Research Laboratories, Eastman Kodak Company, Rochester, N.Y. 14650*

Investigation of the factors involved in rapid processing at elevated temperature has led to new films and chemical solutions which are specially designed for very rapid processing of cathode-ray-tube recordings. An experimental, laboratory model of a complete rapid processing system was constructed in order to study various aspects of the problem. Using Special Dacomatic Film, Type SO-211, together with a specially formulated developer (MX-509-4) and fixer (MX-509-2) it was possible to demonstrate useful development in less than 2 sec at 140°F, and clearing in less than 2 sec at the same temperature. With rinsing and drying requiring 2 sec each, a processing system is shown to produce rinsed, dried film of high quality in a total time of less than 8 sec.

50 **Rapid Access Hard Copy from CRT Displays,** E. P. SMITH, R. P. MASON, AND W. L. KACIN, *Photomechanisms, Inc., Huntington Station, N.Y.*

A newly produced equipment combines the photographic sensitivity and rapid pulldown ability of 35-mm film with moderate cost of electrostatic paper to generate hard copy from on-line displays or TV systems. The unit will accept several commands per sec and generate prints at the rate of 12 per min with only a 26-sec throughput time.

The newest materials available have been utilized to produce a good tone scale when required in the output print. Equipment features, operation, and applications are presented.

51 **A Rapid-Access Kodak Bimat Process,** L. W. TREGILLUS AND R. L. WHITE, *Research Laboratories, Eastman Kodak Company, Rochester, N.Y. 14650*

The Kodak Bimat Process may be applied to the rapid, continuous production of positive images in cathode-ray-tube recording without the use of free liquids. The Bimat Film, charged with the processing chemicals held in a hydrophilic layer, is placed in contact with the just-exposed negative, separated and dried. Sensitometric control is obtained by adjustment of contact time, between 10 and 30 sec, and the temperature, between 110 and 130°F. The design of the processing equipment must encompass the principles of Bimat processing and the needs of the specific application.

Thursday Afternoon, May 20th

Image Formation and Manipulation

Session Chairman: HOWARD G. SILKMAN

52 **A Mechanical Method for Automatically Maintaining the Focus of an Optical System,** W. E. WHITE AND E. A. GEIER, *Research Laboratories, Eastman Kodak Company, Rochester, N.Y. 14650*

This paper describes a method of maintaining the focus of an optical system when one conjugate is fixed and the problem is to correct for adventitious variations in the second conjugate. The method is especially applicable to slide projectors, where the adventitious variations arise from variations in slide construction and position. It consists in directing a weak jet of air into the space between the slide and a curved reference surface (the face of the condenser) close to the film, where the air flow is restricted so that the pressure of the emergent air can be used as an index of the exact position of the slide with respect to the projection lens. A gage to measure this pressure is associated with a servomechanism for restoring the position of the slide to a few thousandths of an inch—far closer than can be detected from the sharpness of the screen image.

53 **Computer Simulation of a Photo-Optical, Image-Forming System,** DIETER P. PARIS, *International Business Machines Corporation, Systems Development Division, San Jose, Calif.*

A program was developed to facilitate the simulation of (one-dimensional) images in a photo-optical, image-forming system. The single (or cascaded) system may consist of any combination of linear or nonlinear components such as lenses, emulsions, and components, described by their spread function or optical transfer function. Design goals are: (1) simplicity of the input language, in which the user specifies his particular system configuration to the program; (2) capability for requesting intermediate output at any point in the sequence of systems components; (3) repeat runs with varied parameters.

54 **Dodging Control by Autogenous Masking,** SEYMOUR L. HERSH AND SUSAN CLEAVES, *U.S. Army Electronic Laboratories, Fort Monmouth, N.J.*

An evaluation of a dodging technique using simultaneous exposure and development is discussed. During the process, developed silver acts as a mask on the subsequently continuing exposure. Methods for sample preparation, control of dodging, and a sensitometric evaluation are presented. Process automation techniques are proposed.

55 The Effect of Special Development Procedures on the Physical Properties of Radiographic Emulsion Grains, WILLIAM L. MCLAUGHLIN, *Radiation Physics Division, National Bureau of Standards, Washington, D.C.*

The radiographic response can be enhanced somewhat following exposure, through latensification or by means of special development techniques. In the present study, the reasons for the greater sensitivity of the specially treated emulsions are investigated through examination of developed emulsion grains. A sensitive commercial radiographic film was given small gamma-ray doses and, following special latensification or development, was subjected to analyses of grain properties (grain concentration, area density of developed silver, and photometric equivalent) and to photo- and electron micrography. The response enhancement in the case of latensification is found to be caused by a rapid increase in grain size with exposure; with special physical development techniques, it is related to the rise in the number of grains developed.

56 The Direct Image in Vesicular Photography, NORMAN T. NOTLEY, *Kalvar Corporation, New Orleans, La.*

There are two routes to the direct copy vesicular image—reversal processing and flash processing. In the first, an image defining exposure produces a latent image of dissolved nitrogen which is allowed to diffuse out from the film before an overall exposure and development. Flash processing eliminates the need for diffusion. The activation energy of the sensitizer is absorbed from the flash and is liberated together with the Decomposition Heat of the sensitizer (196 cals/g) in an adiabatic reaction which can give an instantaneous temperature rise localized in the imaging area of perhaps 220°C and cause selective development. The direct image is obtained, developed, and fixed in just two steps, an image defining exposure from an incandescent or arc source and an overall exposure to xenon flash tube. Gamma is adjustable between 2 and 4 without significant effect on the maximum or minimum densities, just by varying the voltage on the flash.

57 **A New High-Resolution, High-Speed, Continuous Contact Printer,** RICHARD A. WALKER, *Houston Fearless Corporation, Los Angeles, Calif.*

This paper will describe a new high-speed continuous contact printer capable of achieving very high resolution photographic reproductions. The heart of the printer is a large optical-quality glass drum and a second rubber-coated contact drum. The original film-and-print stock sandwich are kept in intimate contact by hydraulic cylinders on the contact drum, while the film is transported by driving the glass drum. Other aspects of high resolution contact printing, such as the nature of the light source and "liquid-gate printing," will also be discussed. Two operational printers will be described. The first is a continuous contact printer capable of achieving 400 l/mm on 70 mm–9½ in. wide roll film at printing speeds up to 120 ft/min. The second printer is a multi-station printer with four printing stations arranged around the periphery of the drum in order to make four simultaneous prints on a single pass of the original film thereby achieving an effective output speed of 480 ft/min.

Friday Morning, May 21st

Further New Theory, Mechanisms and Materials

Session Chairman: HEINZ F. NITKA

58 **Photographic Development from the Viewpoint of Franck-Condon Electron Transfer,** J. Q. UMBERGER, *Photo Products Department, E. I. du Pont de Nemours & Company, Inc., Parlin, N.J.*

Hydroquinone actively develops silver via the symmetrical anions, Q^- and $Q^{\cdot -}$ (radical), readied for *quick* electron transfer by proton removal. The unsymmetrical anion HQ^-, lacking resonance-stabilization during electron transfer, develops silver at a rate only $\frac{1}{100}$ that of $Q^{\cdot -}$. Because Q^- is slow in adsorption, it develops with a rate about $\frac{1}{10}$ that of $Q^{\cdot -}$. It approaches the $Q^{\cdot -}$ rate when cationic surfactants or dyes are present. Since atomic rearrangement is involved, SO_3^- combines "slowly" with oxidized developers. Thus $Q^{\cdot -}$ contributes to hydroquinone's contrasty development and superadditivity in mixtures. Two types of superadditivity are delineated, *moderated* and *explosive,* depending on SO_3^- concentration.

59 **Nonlinear Optical Effects in Silver Halides,** H. D. HUNT AND R. FITZSIMMONS, *Photo Products Department, E. I. du Pont de Nemours & Company, Inc., Parlin, N.J.*

Double photon absorption (a nonlinear process) by silver halide emulsions at 77°K is evident from the blue and green luminescence produced by red ruby laser irradiation. The emission under certain conditions is proportional to the square of the laser power. A prior exposure to ultraviolet radiation enhances this luminescence. The enhancement is a linear process in which a red photon ejects a trapped photoelectron. Double photon absorption as well as ultraviolet absorption produce trapped electrons. Silver halide emulsions prepared in various ways were examined.

60 **Syneresis in Gelled Photographic Emulsions and in Gelatin Gels,** EDGAR B. GUTOFF, *Emulsion Laboratory, Polaroid Corporation, Waltham, Mass.*

Syneresis, the exudation of a liquid by a gel, can be reduced or avoided in gelled emulsions as in gelatin gels by maintaining a high gelatin concentration and eliminating

the use of dehydrating agents such as methanol. Syneresis is most severe at the isoelectric point. The silver halide grains in the emulsion act as an inert diluent with regard to syneresis. The adhesion of the gel to the walls of the container and also additions of electrolytes reduce syneresis. The properties of the gelatin affect syneresis.

61 **The Use of Simultaneous Latensification for the Photographic Detection of Threshold Information,** J. C. MARCHANT, *Research Laboratories, Eastman Kodak Company, Rochester, N.Y. 14650*

The threshold detection limit of most high-speed negative films can be extended by latensification. The purpose of this paper is to show that the threshold limit can be extended even further when the latensification exposure is made simultaneously with the image exposure rather than before or after. It will be shown that, by using this technique, cathode-ray-tube traces can be recorded with sweep speeds up to 5 × greater than those which are normally just detectable.

62 **A New, Simplified Method for the Sensitometry and Grading of Photographic Papers,** YASUSHI OHYAMA, *Mitsubishi Paper Mills Ltd., Photo and Repro Department, Tokyo, Japan*

A simplified method using the two terms, "Principal Exposure Scale" (PS) and "Steep Scale" (SS), for the evaluation of gradational characteristics and the term, "Standard Grade Number" (Gs), derived from PS for the grading of various photographic papers is proposed. As the point which determines the sensitivity, the midpoint of density range corresponding to PS is chosen. The method is suitable for an automatic determination of characteristics, and the idea is consistent with the DIN proposal and not incompatible with the ASA method. The PS values are almost identical with the "Partial Exposure Scale" (PES) values recently introduced by Sweet et al. and Carnahan.

63 **Permanence of Processed Estar Polyester Base Photographic Films,** P. Z. ADELSTEIN AND J. L. MCCREA, *Eastman Kodak Company, Kodak Park Works, Rochester, N.Y.*

The use of photographic films as permanent records is of importance to a great many archivists. However, there has been little experience with the newer type polyester supports. Studies have been made on the chemical sta-

bility of Estar polyethylene terephthalate and it compares very favorably with cellulose triacetate. No effect of the base on the stability of the processed emulsion layer or silver image was found. Adequate adhesion between gelatin emulsion and polyethylene terephthalate is more difficult to obtain. However, it is believed that Estar base films have satisfactory emulsion adhesion when stored under moderate conditions.

64 **A Gold Protective Treatment for Microfilm,** R. W. HENN AND BERNADETTE D. MACK, *Eastman Kodak Company, Rochester, N.Y.*

Microfilm may be protected against oxidative attack and atmospheric gases by treatment with an acid solution of an aurous-thiourea complex. The quantity of gold entering the image is sensitive to time of treatment, agitation, and to the gold concentration of the solution, but is insensitive to the nature of the emulsion, image density, temperature, and mixing or formula variations. It is concluded that the rate-determining step is the diffusion of the gold protective solution into the emulsion.

65 **The Properties of Gold-Treated Microfilm Images,** R. W. HENN AND D. G. WIEST, *Eastman Kodak Company, Rochester, N.Y.*

The photographic image is made much more resistant toward oxidation or reaction with atmospheric gases by treatment with a gold protective solution which deposits a layer of gold on the grains. A typical solution contains gold chloride, thiourea, and tartaric acid. The image is further stabilized, and some physical protection induced, when a formaldehyde supplementary hardening bath is used after the gold treatment. The gold treatment imparts a rather more neutral image tone, but does not increase contrast nor decrease sharpness. Gold-treated films, with and without a formaldehyde after-bath, have been subjected to a series of accelerated tests employing oxidizing agents and moist incubation conditions. Gold-treated films showed marked resistance in all tests. However, the variation employing the supplementary formaldehyde treatment showed marked advantages in resistance to strong peroxide atmospheres.

Friday Afternoon, May 21st

Engineering Exhibits Presentations

Session Chairman: WOODLIEF THOMAS, JR.

66 **Laboratory-Scale Emulsion Coating Device,** T. T. HILL, *Consultant, Rochester, N. Y.*

For laboratory-scale coatings of photo emulsions (or nonsensitive layers) onto flexible supports (paper, film-base, etc.), this is a smooth-surfaced block with temperature control and a vacuum-channel for paper holddown during coating. The separate coating-head used with the block will also be shown.

67 **Laboratory-Scale Photo Emulsion Washing Setup,** T. T. HILL, *Consultant, Rochester, N.Y.*

For laboratory scale gelatin–silver halide emulsions which need washing, a simple, easily cleaned and easily used setup is made from plastic laboratory equipment, replacing the awkward, unsafe glass "percolator" cones. It is usable in batteries.

68 **Two Electronic Image Motion Stabilization Systems,** E. R. ARAZI, *Itek Corporation, Lexington, Mass.*

One system is a hand-held 60 power monocular where the image is electronically stabilized despite vibration of the instrument. The second system is a small telescope equipped with an electronic image motion stabilization and tracking system. A test target is placed a few yards away and mechanically vibrated in high frequency random noise. The system stabilizes the image to its original sharpness. This is analogous to the situations in high acuity space photography in the presence of atmospheric scintillations, or vibration of the telescope, etc.

69 **Photoelastic Analysis of a Solid Propellant Rocket Grain Model Using Photoelasticity,** H. P. ADAM, *Douglas Aircraft Co., Inc., Santa Monica, Calif.*

Photoelasticity is a tool used to analyze stresses and strains in complicated structures. When a birefringent plastic model representing the cross-section of a solid propellant rocket grain is loaded with external pressure and viewed in a polariscope, a fringe pattern is observed. The fringe pattern provides the necessary data for ob-

taining stress distributions and the stress concentrations. Photographs of these fringe patterns supply the original recorded data taken for this type of study.

70 **70-mm Film Processor for Airborne Application,** R. BUCKINGHAM AND A. MILLER, *Chicago Aerial Industries, Barrington, Ill.*

The processor, developed under contract for the U.S. Army Electronics Research and Development Laboratories, Ft. Monmouth, N.J., and designated EH-51, is an airborne 70-mm film processor which operates at continuously-variable film rates from ½ to 75 ft/min while providing a constant image access time of 12 sec. The processor has five principal innovations in operation: (1) the use of continuous liquid monobath processing of 500 ft of 70-mm film; (2) the method of processing by a unique free loop immersion of the film in the monobath without internal rollers, elevators, and guides; (3) continuously-variable and accurately-controlled film drive over a velocity range of 150 to 1; (4) a specially-developed liquid seal permitting operation in any attitude while transporting and processing film; and (5) small size and weight as compared to conventional free liquid systems.

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